Wave-particle duality paradox is solved using mutual energy and self-energy principles for electromagnetic field and photon

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Abstract

The particle and wave duality is solved through the self-energy and the mutual energy principles. Welch has introduced the time-domain reciprocity theorem in 1960. The author have introduced the mutual energy theorem in 1987. It has been proved that the above two theorems are same theorem in time-domain or in Fourier domain. The author believe there is an energy flow from transmitting antenna to the receiving antenna. Hence this theorem is a energy theorem instead of a mathematical theorem i.e. the reciprocity theorem. The author found that the mutual energy is the additional energy when the two waves are superposed comparing to the situation when the two waves alone stayed in the space. It is often asked that if the two waves are identical what is the energy after the two waves are superposed, 4 or 2 times? The author's answer are 2 or 4 depending whether the sources of the waves are involved or not. However the author noticed that a more important situation, which is the superposition of two waves: one is retarded wave sent from the emitter, another is the advanced wave sent from the absorber. This situation actually described the photon. The author have found that, instead there are two photons the retarded photon and the advanced photon like some author believed, there is only one photon. The reason is that the two waves the retarded wave and the advanced wave they both bring one photon energy are sent to the space, but these energy are returned with the time-reversed waves. The additional energy because of the superpose process of the two waves is just with 1 photon's energy instead of 2 photon's energy. This energy is sent from the emitter to the absorber. These build the author's photon model. This photon model is proved by the author through the notice of the conflict between the energy conservation and both the superposition principle and the Maxwell equations for single charge. This conflict force the author introduced the mutual energy principle and the self-energy principle. Self-energy principle tell us the self-energy (the wave's energy before superposed) time-reversal return to its source and hence do not transfer any energy from emitter to the absorber. The mutual energy principle tell us that transferring the energy from the emitter to the absorber is only done by the mutual energy flow. The author also proved that the mutual energy flow theorem, which says that the energy transferred by mutual energy flow is equal in any surface between the emitter to the absorber. The wave function collapse process is explained by the two processes together the first is the self-energy time-reversal return to their sources (instead of the targets), the second is that the mutual energy flow brings a photon's energy package from emitter to the absorber. The wave's probability property is also explained that because only when a retarded wave synchronized with an advanced wave the energy can be transferred. The photon energy is transferred only when the retarded wave (one of solution of Maxwell equations) and the advanced wave (another solution of the Maxwell equations) are synchronized, otherwise the two waves are returned by two time-reversal waves. Time-reversal wave are not satisfy Maxwell equations but satisfy the time-reversal Maxwell equations. Hence, 4 time-reversal Maxwell equations which describe the two additional time-reversal waves are added to Maxwell equations. Hence, the photon's package wave is consist of 4 waves which are corresponding to 4 self-energy flows. There are two additional energy flows, which are the mutual energy flows that is responsible for transferring the energy from emitter to the absorber. The time-reversal mutual energy flow which is responsible to bring the energy back from the emitter to the absorber if the absorber only obtained a half photon.

Keywords: Wave function; Collapse; Poynting; Maxwell; Self-energy; Mutual energy; Mutual energy flow; Time reversal; Photon; Electromagnetic; Action-at-a-distance; Advanced wave; Advanced potential; Absorber theory;

1 Introduction

1.1 The wave and particle duality

It is know that the photoelectric effect tell us the light likes a energy packet. The energy of the light is discrete. The Compton effect tell us that the light same as particle when it is received or absorbed, the receive location is very small, the absorber received a momentum, just equal to the momentum when it is sent out from the emitter. This means when the light emitter and received behave completely like a particle. Hence we can say that the light is consists of the particle, i.e. photon. The photon also obey the third law of Newton that means when the photon is emitted, the emitter gives the photon an action, the photon gives an equal amount of the reaction with opposite direction to the emitter. When photon is received the photon will offer the absorber an action, the absorber will give the photon a reaction which has the same amount and with an opposite direction. Moreover the received action from photon is equal to the action from emitter give to the photon. The reaction received by the emitter from photon is equal to the reaction received by the photon at the place of the absorber. Hence action and reaction can be transferred correctly.

However we also know that when light go through the double slits, it can produce the interference pattern. We can reduce the intensity of light, hence, the photon is go through the double slits one by one, the interference patterns still exists if the accumulating time is longer. Hence, light is also a wave. This is referred as the wave and particle duality.

This author is looking for a unified theory to explain the wave and particle duality. It is clear that it is not possible to explain the wave properties using particle theory. But perhaps it is possible to find a special wave that have the properties of particle. The author is looking for a wave it is at very small location when it is emitted or received. This wave should be possible to carry amount of energy and momentum from the emitter to the absorber. In the middle between the emitter and the absorber, the wave should be thick so it can go through the double slits simultaneously.

Up to now, the traditional wave, for example, the retarded wave of Maxwell equation do not satisfy the above requirement. We all know that the retarded wave solved from Maxwell equation spreads to all directions, hence when it is emitted, the total momentum is 0. However when it is received by an absorber, it is clear the wave is sent from the emitter to the absorber direction, hence the moment is not 0. This wave doesn't satisfy the momentum conservation. The energy send by the emitter does not all travel to the absorber. Most energy sent from emitter go to all direction of infinity instead of go to the absorber. The wave in the time it is received is also not focus to a very small region. Hence this kind wave cannot be used to describe a particle and hence is not what the author looking for.

1.2 Two different electromagnetic field theory

There are two different electromagnetic field theory. The first is the field theory which is first introduced by Faraday and later it is introduced by Maxwell in 1865. The second is the action at a distance which are introduced by Weber 1848 [32] and later by Schwarzschild, Tetrode and Fokker [28, 10, 30]. It is clear that field theory from Faraday and Maxwell are mathematically convenient and hence produced a lot of good results for example, from which the wave equation is derived. The calculation from the theory of action-at-a-distance is not so convenient compare to the field theory, however it has the advantage to offer the correct mechanic properties. The action and reaction is equal and in the opposite direction (third law of Newton). It is said that the Maxwell equations can be derived from the Weber's electromagnetic theory [32]. Wheeler and Feynman also proved it is possible to obtains Maxwell equations from the action-at-a-distance theory of [28, 10, 30]. However it is strange that up to now no theory from the field of Faraday and Maxwell can obtained energy conservation, moment conservation, or Newton's third law for the photon.

In case there are two charges that are interaction, for example, if there are two charges one is emitter another is absorber. It is clear that the wave send out from the emitter spread to all directions, hence the total momentum is 0. But in the place of absorber, the wave is from the emitter to the absorber and hence, the momentum is nonzero. The momentum has the direction from the emitter to the absorber. Hence, the momentum sends from the emitter does not equal to the momentum received from the absorber. Hence, the momentum is not conserved.

According to the field theory of Faraday and Maxwell, the energy received from the absorber is only part of the energy sends out from the emitter. Most of wave energy sends from the emitter goes out of our universe. The energy is not conserved. In order to make energy conserved, the concept of wave function collapse is introduced. The energy sends to the whole universe is collapsed to the absorber. The wave function collapse can make the energy conserved. However the wave function collapse as a physics process, there is no any mathematical description or formula can be given. Hence, this author does not accept the concept of the collapse of the wave function.

The field theory of Faraday and Maxwell can also difficult to explain the action and reaction. In the view of photon, we know that in the place of the emitter, the emitter gives the photon a action, the photon gives the emitter a reaction. In the place of absorber, the photon offers the absorber an action, the absorber offers the photon a reaction. Here, the action and the reaction is equal and in the opposite direction. And also the action of the emitter offering to the photon is sent by the photon to the absorber, hence, the absorber received the action. The reaction of the absorber to the photon also offers to the emitter. Hence, the Newton's third law is obeyed. Action is delivered from the emitter through the photon to the absorber. The reaction is delivered also from the absorber to the emitter through the photon. It is extremely difficult to explain the reaction of the absorber giving to the emitter by the retarded wave of Maxwell theory.

From the retarded wave theory of Faraday and Maxwell, field propagation is used between the emitter and absorber. In the beginning, the emitter sends the field, since the field is sent to all direction, the force of the total action is zero, the force of the total reaction of the field to the emitter is also zero. This is OK, Newton's third law is satisfied. When field is received by the absorber the action come from the direction of the emitter to the absorber. The force of the action to the absorber is not zero, the reaction is in the opposite direction. This is also OK, Newton's third law is satisfied. But the action from the emitter to the field is not equal to the action from the field to the absorber. The reaction of the absorber to the field is also not equal to the reaction of the field to the emitter. Hence, the action and the reaction is not delivered correctly like the photon does. Hence from current retarded field theory of Faraday and Maxwell, we cannot obtained the same effect same as the photon can offer.

1.3 Power of a system with N charges

There are two conflictive theories for electromagnetic fields. One is the theory of Maxwell equations, another one is the theory of the action-at-a-distance. Maxwell's theory claim that the field can be send from its source. The field can be solved with Maxwell equations when the source is known. A single charge can create the electromagnetic field and this field can exist independent to its source. If we measured the field with a test charge, after the measurement when the test charge is removed, the field we have measured still exists and does not vanish. In other hand Schwarzschild, Tetrode and Fokker introduced the theory of action-at-a-distance, it is also referred as direct interaction[28, 10, 30]. In the theory of action-at-a-distance, single charge cannot send the wave out. Tetrode said, "If the sun stayed in empty space, it can not send light out". The sun can send light is because the absorber absorbs the light energy. The absorber can send advanced wave to receive the energy. Dirac has applied advanced wave to explain the damping force or self-force for the radiation of a moving charge[9]. Wheeler and Feynman, designed the absorber theory according to the the principle of the action-at-a-distance. In the absorber theory the electromagnetic field has no its own freedom and the electron charge does not only sends the retarded waves to the future but also sends advanced wave to the past [1]. Wheeler and Feynman also introduced the concept of the adjunct field[2]. In the action-at-a-distance principle, the electromagnetic field is an adjunct field which has no its own freedom. This field is an action, which take place at least between two charges: the emitter and the absorber. With only one charge, it cannot define an action, hence, a field. Hence, we can measure an electromagnetic field with a test charge, but after the measurement, when the test charge is removed, according to the principle of the action-at-a-distance, the field is not defined. Since the action can only be created by at least two charges. Now if there is only one charge, the source charge, it cannot produce a action! Field can independent exist in the space or it is only bookmark for a action which can only exist at least between two charges, this debate has continued for 100 years until now. In this article the author will answer the question of this debate.

What about the measured electromagnetic field, after the test charge is removed? According to Maxwell's theory the measured field is still there, but according to action-at-a-distance the field is not defined or doesn't exist. Which theory is correct? Even there are many scientists supports the action-at-a-distance and the absorber theory, they still cannot deny the Maxwell's theory, because to answer this question cannot be done by a experiment, for example test the field by a single charge. None knows the electromagnetic field exist or not in the time we have removed the test charge. This question appears as a philosophy problem instead of a problem of physics.

This is major problem of the classical electromagnetic field theory. Many problem related this problem, for example, (1) wave and particle duality, (2) quantum entanglement, (3) is the superimposition principle correct or not? (4) the electromagnetic field is a real wave or a probability wave? advanced wave exist or not and wave function collapse.

This author endorse the concept of the action-at-a-distance and introduced the mutual energy principle[17]. For sure we know that the Maxwell's theory has great value. Hence this author has combined the principle of action-at-a-distance and the Maxwell's theory together in the mutual energy principle. According to the mutual energy principle, the electromagnetic fields still can be produced by one charge. However the fields must satisfies the mutual energy principle instead of Maxwell equations. A electromagnetic field of a single charge cannot satisfy the mutual energy principle. In order to satisfy the mutual energy principle, there are at least two charges, one is the emitter, another is the absorber. The emitter can sends the retarded wave. The absorber can send advanced wave, When these two wave take place in the same time or they are synchronized together, the mutual energy principle is satisfied and there are mutual energy flow which is produced between the emitter and the absorber. The mutual energy principle can be solved to find the retarded wave for the emitter and the advanced wave of the absorber. The two waves both the retarded wave and the advanced waves satisfy two groups of the Maxwell's equations. There must be at least be two group Maxwell's equations, one is for the emitter and another is for the absorber. The time-integral of the mutual energy flow is just the transferring energy between the emitter and the absorber. The photon is nothing else, it is just the mutual energy flow between the emitter and the absorber. In the mutual energy principle, the field still can be created by emitter or by absorber alone, this is like the Maxwell theory. But two fields are required to satisfy the mutual energy principle.

1.4 The mutual energy theorem

Another important origin of the mutual energy principle is from the mutual energy theorems. The work about the mutual energy theorems can be listed as following. W.J. Welch has introduced time-domain reciprocity theorem[31] in 1960. In 1963 Rumsey shortly mentioned a method to transform the reciprocity theorem to a new formula[27]. In early of 1987 this author has introduced the mutual energy theorem [15, 34, 33]. In the end of 1987 Adrianus T. de Hoop introduced the time domain correlated reciprocity theorem[8]. All these theories are same theory in different domain: Fourier domain or in time domain.

1.5 The development of the concept of mutual energy

This author believe the mutual energy theorem is strongly related to the energy in physics instead of a mathematical theorem, for example the reciprocity theorem, which only describes a relation or a transform. Hence the author first call this theorem as mutual energy theorem instead of some kind of reciprocity theorem [15, 34, 33] in 1987. In that time the author spoke about the "mutual energy" is base on the fact in the formula there is the term $E_1(\omega) \cdot H_2^*(\omega)$ that is exactly what we have meet in electric engineering like $V(\omega)I(\omega)^*$, here $V(\omega)$ is voltage and $I(\omega)$ is the current, $\omega$is frequency. In the theory about the transformator, there are also have the term like $V_1(\omega)I_2(\omega)^*$ which is corresponding to the power of the mutual inductance item. In order to illustrate the mutual energy theorem is really a energy theorem, the author also thought to prove the mutual energy theorem from Poynting theorem. It is known that the Poynting theorem is an energy theorem, if the mutual energy theorem can be proved from Poynting theorem, it can be sure also an energy theorem. If it is energy theorem, it should has more meaningful compare to the Lorentz reciprocity theorem. And because from the practice, the directivity diagram of a receiving antenna can be obtained from only the mutual energy theorem or reciprocity theorem instead of the the Poynting theorem, hence the mutual energy theorem should be also more important at the energy transfer between two antenna, i.e., the transmitting antenna and the receiving antenna.

However the author failed to do so. Instead, the author derive the mutual energy theorem from modified reciprocity theorem[11]. This make the mutual energy theorem look like a sub-theorem of the Lorentz reciprocity theorem. This become a flaw in an otherwise perfect thing.

2014 the author comeback to the topic of the mutual energy theorem. First the author found a literature which is very close to the mutual energy theorem, the time domain correlated reciprocity theorem[8] writing by Adrianus T. de Hoop in the end of 1987. The author proved that after a Fourier transform, the time domain correlated reciprocity theorem become the mutual energy theorem. The mutual energy theorem was writing at early of 1987, hence it is also meaningful[15, 34, 33]. Later the author also found the article about time-domain reciprocity theorem[31], which is introduced by W.J. Welch in 1960. It is proved that the time-domain reciprocity theorem[31] is a special case of the time-domain correlated reciprocity theorem[8]. The author also found a article about the new reciprocity theorem [27] which is introduced by Rumsey In 1963 which is similar to the mutual energy theorem. Later this theorem has also been rediscovered many times, for example [13].

It become clear that all other people call the mutual energy theorem as some kind reciprocity theorem. Only the author call it a energy theorem, hence I have to prove it is really a energy theorem. In 2014 this author wrote the online publication discussed the relationship between the reciprocity theorem, the mutual energy theorem and the Poynting theorem[19], in which the author proved the mutual energy theorem from the Poynting theorem. Another important thing is that the author also noticed that, if $f_1(t) = f_1(x-vt)$ and $f_2(t) = f_2(x-vt)$ are waves for example the forward wave, where v is the speed, x is the location, t is the time. Then, a correlation formula $\int_{t=-\infty}^{\infty} f_1(t+\tau)f_2(t)dt$ is a time integral of multiplication of this two forward waves with a time difference τ. Hence, inside the integral the two waves are all move forward. However the convolution $\int_{t=-\infty}^{\infty} f_1(\tau-t)f_2(t)dt$ is time integral with a multiplication of a forward wave with the time-shift back-ward wave. In the Fourier domain or (frequency domain), the correlation $\mathcal{F}\{\int_{t=-\infty}^{\infty} f_1(t+\tau)f_2(t)dt\} = f_1(\omega)f_2^*(\omega)$, which is corresponding a output power, where $\mathcal{F}\{\cdot\}$ is Fourier transform. It is reasonable that a output power which is corresponding to a multiplication with conjugation of two forward waves. In contrast, the Fourier transform of the convolution of two waves $\mathcal{F}\{\int_{t=-\infty}^{\infty} f_1(\tau-t)f_2(t)dt\} = f_1(\omega)f_2(\omega)$ are multiplication without conjugation. Hence it is clear, that in the mutual energy theorem, the multiplication is with conjugation, which is corresponding to two wave move in the forward direction. But in the Lorentz reciprocity theorem the multiplication of two waves are without conjugation, which is corresponding the two wave one is forward and another is backward. For example, in the circuit, if voltage V and current I have the multiplication with conjugate $V(\omega)I(\omega)^*$ which is corresponding to two forward waves and hence corresponding to a power or energy output. In contract, $V(\omega)I(\omega)$ is corresponding a forward wave and backward wave which is nothing to do with the power and energy. Now it is clear the following mutual energy theorem is a energy theorem,

$$-\oiint_{\Gamma}(\boldsymbol{E}_1\times\boldsymbol{H}_2^*+\boldsymbol{E}_2^*\times\boldsymbol{H}_1)\cdot\hat{n}d\Gamma=\iiint_V(\boldsymbol{E}_2^*\cdot\boldsymbol{J}_1+\boldsymbol{E}_1\cdot\boldsymbol{J}_2^*)dV \qquad (1)$$

But the Lorentz reciprocity theorem[3, 4, 11],

$$\oiint_{\Gamma}(\boldsymbol{E}_1\times\boldsymbol{H}_2-\boldsymbol{E}_2\times\boldsymbol{H}_1)\cdot\hat{n}d\Gamma=\iiint_V(\boldsymbol{E}_2\cdot\boldsymbol{J}_1-\boldsymbol{E}_1\cdot\boldsymbol{J}_2)dV \qquad (2)$$

is not a energy theorem.

After it is clear to the author the mutual energy theorem is indeed an energy theorem, the author now begin to understand that why we can calculate the directivity diagram of the receiving antenna by using the reciprocity theorem instead of Poynting theorem. It is because the mutual energy theorem actually described the energy transferring from the transmitting antenna to the receiving antenna. Since the reciprocity theorem can be obtained by a conjugate transform from mutual energy theorem, it can offer the same directivity diagram of the receiving antenna. The calculation of directivity diagram is also can be done by directly apply the mutual energy theorem. Applying the mutual energy theorem can not only obtain the directivity diagram of the receiving antenna but also can calculate the current on the receiving antenna. On the contrast, the reciprocity theorem cannot be applied to calculate the current distribution on the receiving antenna $\boldsymbol{J}_2$. The triumph of the mutual energy theorem also decrease the value of Poynting theorem as a energy theorem. At lease the energy transfer between the transmitting antenna to the receiving antenna, is correctly described by the mutual energy theorem instead of the Poynting theorem.

The author also notice that in the proof of the surface integral are 0, W.J. Welch introduced the concept of advanced wave. He point out the retarded wave $\xi_1=\{\boldsymbol{E}_1,\boldsymbol{H}_1\}$ and the advanced wave $\xi_2=\{\boldsymbol{E}_1,\boldsymbol{H}_1\}$ cannot reach in infinite big sphere Γ in the same time and hence the surface integral in the following time domain reciprocity theorem will vanish.

$$\begin{aligned}&-\int_{t=-\infty}^{\infty}\oiint_{\Gamma}(\boldsymbol{E}_1\times\boldsymbol{H}_2+\boldsymbol{E}_2\times\boldsymbol{H}_1)\cdot\hat{n}d\Gamma dt\\&=\int_{t=-\infty}^{\infty}\iiint_V(\boldsymbol{E}_2\cdot\boldsymbol{J}_1+\boldsymbol{E}_1\cdot\boldsymbol{J}_2)dVdt\end{aligned} \qquad (3)$$

This proof is much nature compare when author to prove the surface integral vanish compare in Fourier domain to prove the surface integral in Eq.(1) vanishes. The proof in the Fourier domain looks like it just very lucky the surface integral vanished. The author has the felling if for example the frequency of the signal just change a little bit the theorem will be violated. However advanced wave is difficult to be understood. In order to apply this theorem to the antenna, the first question to the author is that does the receiving antenna really sends the advanced waves? The author originally has the concept that a wave can converge to a point, this wave can be called receiving wave, or convergent wave. The different from the convergent wave to the advance wave is that for a convergent wave the current $\boldsymbol{J}_2$ can only influence by the wave, but for an advanced wave the current $\boldsymbol{J}_2$ is the source, it will influence the wave when the wave is sent out. Since this wave is sent to the past, a current event can influence a past event. This violate the causality.

Even their has some confusion to the author, the author believe the energy transfer for two antenna the transmitting antenna and the receiving antenna is done through the mutual energy theorem. The author also thought about the photon, which actually is a mall system of two antenna, the emitter is a small transmitting antenna, the absorber is a small receiving antenna. The energy is transferred from emitter to the absorber through these two small antennas. The transferred energy is the photon.

In the middle of 2015, this author begun to search the publications about advanced potential, advance field or advanced wave. Among this kind of work, this author noticed the book of Lawrence Stephenson[29] and read it with great interesting especially the topic about the advanced potential and his talk about the reciprocity theorem. To this author his talk about the reciprocity theorem, the author knows actually should be for the mutual energy theorem. Afterwords this author noticed the absorber theory of Wheeler and Feynman[1, 2, 12] After read all these publications, the author begin to understand the advanced wave and believe it is a real thing in physics. This author begun to work at building a photon model with classical electromagnetic filed theory[24, 25]. In the same time the author noticed the work of John Cramer's transactional interpretation for quantum physics [6, 7]. He has many interesting idea ahead and similar to the author.

After it is clear to the author that the antenna energy is transferred by the mutual energy, the author asked whether or not there is a energy flow to go from the emitter to the absorber? It is proved there is a mutual energy flow[24, 25]. The time integral of the mutual energy flow is equal at any surface between two antenna, the transmitting antenna and the receiving antenna. The author call this the mutual energy flow theorem, this is a theorem further stronger than the mutual energy theorem, it further prove the energy transfer from the transmitting antenna to the receiving antenna is through the mutual energy flow theorem.

All above this author's work is about the mutual energy, and mutual energy flow. However in the electromagnetic field in order to produce the mutual energy and mutual energy flow, the self-energy and the self-energy flow will be created as a side effect. The self-energy flow is the field of the single charge. This energy flow has been spread to the entire space. This will cause that the energy of the charge will be lost and go out off our universe. This is unbelievable. A guess to solve this problem is that this self-energy wave collapse to its target. The retarded wave from the emitter will collapse to the absorber. The advanced wave of the absorber will collapse to the emitter. This author do not support the concept about the wave function collapse. Since if there are partition board between the emitter and the absorber. If there is a hole in each partition board. The light can go through these holes from the emitter to the absorber. According to the wave function collapse, the wave must collapse at each holes. The wave collapse once at the absorber is strangle enough, if the wave collapse N times in all holes, that is unbelievable. Hence this author trend that the self-energy flow collapse to its source that means the wave is time-reversal returned. About the thought that the self-energy flow is time-reversal returned also written on the photon model of the author [24, 25].

In April of 2016 when the author begun to check the Poynting theorem energy output of N charges, the author noticed that the formula obtained from N charges has a over estimation about the energy. The author immediately realized that there is bug of Poynting theorem and also the bug of current the theorem of the retarded wave of Maxwell. The author have upload one online publication[17]. By solving this bug, it is clear to the author that the self-energy flows described by the Poynting theorem are time-reversal returned, instead of collapse to its target. This time-reversal process can be described with time-reversal Maxwell's equations. By the wave time-reversal Maxwell equations are not Maxwell equations. They are other equations look like Maxwell equations.

In the same time the author also made some other online publication which are one article to check whether the reciprocity theorem is correct or the mutual energy theorem is correct in lossy media[20]. The conclusion is that the mutual energy theorem can be extended to the lossy media, but the reciprocity theorem cannot. The author also wrote an article about photon and particle duality [22].

The theory about mutual energy, mutual energy theorem, mutual energy principle and mutual energy flow, self-energy principle are also widen to quantum physics theory [18]. A new interpretation for quantum physics using the mutual energy flow is shown [16][23].

The author also introduced a experiment method to test the advanced wave [21].

1.6 Self-energy, mutual energy and time-reversal process

If there are two fields, when they are superposed, there are

$$\boldsymbol{E} = \boldsymbol{E}_1 + \boldsymbol{E}_2 \tag{4}$$

$$\boldsymbol{H} = \boldsymbol{H}_1 + \boldsymbol{H}_2 \tag{5}$$

As a example we assume that $\xi_1 = [\boldsymbol{E}_1, H_1]$ are retarded field and $\xi_2 = [\boldsymbol{E}_2, H_2]$ is advanced field. The Poynting vector are,

$$\boldsymbol{E} \times \boldsymbol{H} = (\boldsymbol{E}_1 + \boldsymbol{E}_2) \times (\boldsymbol{H}_1 + \boldsymbol{H}_2)$$

$$= \boldsymbol{E}_1 \times \boldsymbol{H}_1 + \boldsymbol{E}_2 \times \boldsymbol{H}_2 + (\boldsymbol{E}_1 \times \boldsymbol{H}_2 + \boldsymbol{E}_2 \times \boldsymbol{H}_1) \tag{6}$$

In the right side of the formula, the first item $\boldsymbol{E}_1 \times \boldsymbol{H}_1$ corresponding the self-energy and self-energy flow of the retarded wave. The second item $\boldsymbol{E}_2 \times \boldsymbol{H}_2$ is corresponding to the self-energy and self-energy flow of the advanced wave. The third item $(\boldsymbol{E}_1 \times \boldsymbol{H}_2 + \boldsymbol{E}_2 \times \boldsymbol{H}_1)$ is corresponding to the mutual energy and mutual energy flow. Hence the mutual energy is corresponding the additional part of energy because the two field is superposed. The mutual energy and mutual energy flow can also be produced if the two fields are all retarded or all advanced.

This author believe that advanced wave and retarded wave can be superposed and interfere with each other. Many other authors even do not believe the advanced wave, hence they will not think about whether or not a advanced wave can superposed with a retarded wave. The two retarded waves or two advanced waves can also produce the mutual energy and also mutual energy flow, but the most important mutual energy flow are the mutual energy flow produced by a retarded wave and an advanced wave. This kind mutual energy flow is responsible for the energy transfer. In this article the author will prove that the self-energy and self-energy flow do not produce or contribute to the energy transfer between the emitter and the absorber.

The self-energy flows will time-reversal return to their sources, either emitter or absorber. time-reversal return is a process in which the sent wave returns back from the whole space to its source satisfying the time-reversal Maxwell equations. The time-reversal Maxwell equations are not a Maxwell equations. In this article the wave function collapse process is that the wave sent form its source to the whole space suddenly go to its target. Hence the retarded wave sent from emitter will collapse to its absorber. The advanced wave sent from the absorber will collapse to its emitter. For the time-reversal process the wave sent from the emitter will time-reversal return to the emitter. The wave sent from the absorber will time-reversal return to the absorber. Hence time-reversal process is a total different process compare to the collapse process. This article will talk more details about the time-reversal process. The author believe the self-energy time-reversal process together with the mutual energy flow transfer the energy from the emitter to the absorber will be equivalent to a collapse process. However the collapse process cannot be described by any equations, a time-reversal process can be described by time-reversal Maxwell equations. Hence a time-reversal process is much more “real” than a collapse process. It should point out the time-reversal Maxwell equations are not Maxwell equations, they only looks like the Maxwell equations. The author believe corresponding to the retarded wave and the advanced wave their are two time-reversal processes which can be described by the time-reversal Maxwell equations. The author believes there exist no the collapse process for photon, there only exist the time-reversal processes and a energy transfer process described by the mutual energy flow.

1.7 What will be done in this article

In this article the author will review the whole concept about the mutual energy, mutual energy theorem, and mutual energy flow theorem, mutual energy principle and the self-energy principle. The author will try to to persuade the reader to accept these new theories. Considered the author has overturned many our traditional principles, for example the superposition principle is wrong, the Poynting theorem does not send energy out, the Lorentz reciprocity theorem is not a physical theorem because it change the advanced wave (which is real) to a retarded wave (which is false), wave function collapse need to be replace by two time-reverse-return process and a mutual energy flow process, Maxwell equations are remedied by adding 4 new equations, these all together are too difficult to be accept by any readers, the author will explain the concepts with extremely more details.

In this article the author also introduced some new concept which are following,

(1) The author first introduced the ideal of strong mutual energy theorem. This will distinguish the original mutual energy theorem[15, 34, 33] with the new mutual energy theorem derived from the mutual energy principle. The original mutual energy theorem tell us there is a part of energy sent out by the transmitting antenna which is received by the receiving antenna. This theorem looks trivial. It is clear there are some energy will be sent from the transmitting antenna to the receiving antenna. The new mutual energy theorem tell us all the energy sent from emitter is received by the absorber. There is no any energy has been lost in the empty space. Hence, the new mutual energy is much stronger and meaningful compare to the original mutual energy theorem.

(2) the effect of the action-at-a-distance is shown by the strong mutual energy theorem. Especially the recoil force which is the effect of the mutual energy flow. Since the mutual energy flow is consist of the advanced field, it has ability to offer a recoil force to the emitter, this recoil force happens at the current time that the emitter sends a retarded wave out. The emitter sends the retarded wave out, the retarded wave reach the absorber need some time T, but the absorber sends the advanced wave back to the emitter which needs a negative time $-T$, the total time when the action from the emitter to the absorber and the reaction from absorber to the emitter is a time $T + (-T) = 0$.

(3) In this article we begin added a new kind of mutual energy and mutual energy flow, the time-reversal mutual energy flow. This kind mutual energy flow can be used to explain if there is a race situation, hence the two absorber all received only a half photon. In this situation, the half photon needs to be returned. This will guarantee the transactional process of the whole photon energy package can be implemented.

(4) Mechanics law of Newton has been explained. Newton third law is that the force of action and the force of the reaction is equal and in the opposite direction. This law can be expanded as a remote law, the two objects can separated a distance. In this case, there still exist the expanded third law. That is the recoil force (reaction) which is equal to the force (action) to the

remote object. The direction of the recoil force is in the opposite direction of the action force.

In this article when we speak about Maxwell equations, we will explicitly distinguish the two different situations, the first is the Maxwell equations for N (many) charges and the second situation Maxwell equations is only for a single charge. The first is written as MCMEQ (many-charge Maxwell equations), the second is written as SCMEQ (single-charge Maxwell equations). If the electromagnetic fields can be superimposed, it is easy to prove MCMEQ from SCMEQ. Hence we do not need to distinguish these two concepts, however in this article we will question the superimposition principle, hence we have to distinguish these two situations.

2 Classical electromagnetic field theory

2.1 The confusion about the superposition principle

The field theory need superposition principle. However it is possible the superposition principle has the problem. Now let us to see the concept of the electric and magnetic field. Assume there are N charges in the system, we can calculate the electric field in the place $\boldsymbol{x}$ by superposition principle,

$$\boldsymbol{E}(\boldsymbol{x}) = \sum_{j=1}^{N} \boldsymbol{E}(\boldsymbol{x}_j, \boldsymbol{x}) \tag{7}$$

where $\boldsymbol{x}_j$ is the position of the charge q_j, $\boldsymbol{E}(\boldsymbol{x}_j, \boldsymbol{x})$ is the charge q_j produced field in the position $\boldsymbol{x}$, the above definition looks good. The total field can be obtained by the supposition. However if we need to know the field at a the position of any charges, we can write the above formula as,

$$\boldsymbol{E}(\boldsymbol{x}_i) = \sum_{j=1, j\neq i}^{N} \boldsymbol{E}(\boldsymbol{x}_j, \boldsymbol{x}_i) + \boldsymbol{E}(\boldsymbol{x}_i, \boldsymbol{x}_i) \tag{8}$$

but

$$\boldsymbol{E}(\boldsymbol{x}_i, \boldsymbol{x}_i) = \infty \tag{9}$$

if the charge is a point charge. Hence we have to change the definition of the field as following,

$$\boldsymbol{E}(\boldsymbol{x}) = \begin{cases} \sum_{j=1}^{N} \boldsymbol{E}(\boldsymbol{x}_j, \boldsymbol{x}) & \boldsymbol{x}_j \notin J \\ \sum_{j=1, j\neq i}^{N} \boldsymbol{E}(\boldsymbol{x}_j, \boldsymbol{x}) & \boldsymbol{x}_j \in J \end{cases} \tag{10}$$

$J = 1, \cdots j \cdots N$, it is the set of the index of the charges. The above definition does also not very satisfy. Many people will ague that is this correct that the field is extended to the any position without a test charge? According to the principle of action-at-a-distance, the action and reaction force can be defined on to a charge, hence the field can only be defined on the charge which is,

$$\boldsymbol{E}(\boldsymbol{x}) = \begin{cases} No\ difinition & \boldsymbol{x}_j \notin J \\ \sum_{j=1,j\neq i}^{N} \boldsymbol{E}(\boldsymbol{x}_j, \boldsymbol{x}) & \boldsymbol{x}_j \in J \end{cases} \tag{11}$$

Hence we have 3 versions of the definition about the field, which is correct? The concept of superposition of the fields is confused. The magnetic field has the same problem we do not discuss it here.

The reason of this confusion is because that if we measure the field we need a test charge. But how can we know if the test charge is removed the measured field is still there or not? According to the principle of action-at-a-distance, if the test charge is removed, the field can not be defined as a real physics property. It is only an ability to give a force when the test charge exists, but it is not some thing real with energy in the space. It is also true for the radiation field, if the absorber received a photon, how can we know that if the absorber is removed, the photon is still there? If the absorber is removed the retarded radiation field can only be a probability wave in quantum physics. It is not any wave with physical energy in the space. That is the reason many people will argue that after the removal of the test charge or the absorber, the field of the wave is not defined. Tetrode has the very famous words, the sun cannot send light out, if it is stayed in empty space alone, it need absorber to absorb the light energy.

From this subsection we are clear that the concept of the field is very confused, actually this means the superposition principle has problems. There not exist this kind of linear fields which can be simply added together in entire space. The superposition can only be done at the place where there are a charge. And the electric field at the position of the test charge is defined by the contribution of the all other charges not include itself.

Without the superposition principle, we can still define fields as a collection of all fields of their charges,

$$\boldsymbol{E}(\boldsymbol{x}) = [\boldsymbol{E}(\boldsymbol{x}_j, \boldsymbol{x}), \cdots E(\boldsymbol{x}_j, \boldsymbol{x}) \cdots] \tag{12}$$

or

$$\boldsymbol{E}(\boldsymbol{x}) = [\boldsymbol{E}_1 \cdots \boldsymbol{E}_j \cdots \boldsymbol{E}_N] \tag{13}$$

we have written $\boldsymbol{E}_j = \boldsymbol{E}(\boldsymbol{x}_j, \boldsymbol{x})$ for simplicity. In this article later, we will continue shown the the problems of the superposition principle.

2.2 Power of a system with N charges

If the charge move and has the speed $\boldsymbol{v}_i$, where i is the index of the charge, we know that,

$$\boldsymbol{J}_i = \rho_i \boldsymbol{v}_i \tag{14}$$

where $\boldsymbol{J}_i$ is the current intensity. ρ_i is the charge intensity. There is,

$$\rho_i = q_i \delta(\boldsymbol{x} - \boldsymbol{x}_i) \tag{15}$$

and hence the current of the charge is,

$$I_i \equiv \iiint\limits_V \boldsymbol{J}_i dV = \iiint\limits_V q_i \delta(\boldsymbol{x} - \boldsymbol{x}_i)\boldsymbol{v}_i dV = q_i \boldsymbol{v}_i \tag{16}$$

we know the power which of single charge is,

$$P(\boldsymbol{x}_i) = \boldsymbol{F}(\boldsymbol{x}_i) \cdot \boldsymbol{v}_i \tag{17}$$

$\boldsymbol{x}_i$ is the position of the charge. $\boldsymbol{F}(\boldsymbol{x}_i)$ is Coulomb's force on i-th charge, which can be given as following,

$$\boldsymbol{F}(\boldsymbol{x}_i) = \sum_{j=1, j\neq i}^{N} \frac{q_i q_j}{4\pi\epsilon_0} \frac{(\boldsymbol{x}_i - \boldsymbol{x}_j)}{||\boldsymbol{x}_i - \boldsymbol{x}_j||^3} \tag{18}$$

where q_i or q_j is amount of charge at the place $\boldsymbol{x}_i$ or $\boldsymbol{x}_j$, write,

$$E(\boldsymbol{x}_j, \boldsymbol{x}_i) = \frac{q_j}{4\pi\epsilon_0} \frac{(\boldsymbol{x}_i - \boldsymbol{x}_j)}{||\boldsymbol{x}_i - \boldsymbol{x}_j||^3} \tag{19}$$

which is the electric field of charge q_j to q_i. Hence, we have

$$\boldsymbol{F}(\boldsymbol{x}_i) = q_i \boldsymbol{E}(\boldsymbol{x}_i) \tag{20}$$

Hence power of charge i is,

$$P_i = q_i \boldsymbol{E}(\boldsymbol{x}_i) \cdot \boldsymbol{v}_i \tag{21}$$

Hence the power of the whole system with N charges is,

$$\begin{aligned} P &= \sum_{i=1}^{N} P_i = \sum_{i=1}^{N} \boldsymbol{E}(\boldsymbol{x}_i) \cdot (q_i \boldsymbol{v}_i) \\ &= \sum_{i=1}^{N} \sum_{j=1, j\neq i}^{N} \boldsymbol{E}(\boldsymbol{x}_j, \boldsymbol{x}_i) \cdot \boldsymbol{I}_i \end{aligned} \tag{22}$$

The above formula is obtained from static electric field, but is is also correct to the radiation fields.

We find when we calculate the power of N charges, we have to use the following summation,

$$\sum_{i=1}^{N} \sum_{j=1, j\neq i}^{N} \tag{23}$$

3 A bug in Poynting theorem for single charge

3.1 The start point of the author's new electromagnetic theory

The author's electromagnetic theory is started from the following 3 conflicted conditions:

(I) The author assumes that the electromagnetic field of the electric charge satisfy SCMEQ,

$$\nabla \times \boldsymbol{E}(\boldsymbol{x}_i, \boldsymbol{x}, t) = -\frac{\partial \boldsymbol{B}(\boldsymbol{x_i}, \boldsymbol{x}, t)}{\partial t} \tag{24}$$

$$\nabla \times \boldsymbol{H}(\boldsymbol{x_i}, \boldsymbol{x}, t) = \boldsymbol{J}(\boldsymbol{x}_i, t) + \frac{\partial \boldsymbol{D}(\boldsymbol{x}_i, \boldsymbol{x}, t)}{\partial t} \tag{25}$$

Here we only consider the two equation in Maxwell equations, since we would like only consider the radiation fields. Where i is the i-th electric charge, $\boldsymbol{x}_i$ is the position of the i-th charge, $\partial = \frac{\partial}{\partial t}$, t is time. $\boldsymbol{E}$ is electric field, $\boldsymbol{H}$ are magnetic H-field. $\boldsymbol{J}$ is electric current intensity, $\boldsymbol{D}$ is electric displacement. $\boldsymbol{B}$ is magnetic B-field. According to the traditional definition there are,

$$\boldsymbol{D}_i(\boldsymbol{x_i}, \boldsymbol{x}, t) = \epsilon_0 \boldsymbol{E}_i(\boldsymbol{x_i}, \boldsymbol{x}, t) \tag{26}$$

$$\boldsymbol{B}_i(\boldsymbol{x}_i, \boldsymbol{x}, t) = \mu_0 \boldsymbol{H_i}(\boldsymbol{x_i}, \boldsymbol{x}, t) \tag{27}$$

$$\boldsymbol{J}_i = q_i \boldsymbol{v}_i \delta(\boldsymbol{x} - \boldsymbol{x}_i) = \boldsymbol{I}_i \delta(\boldsymbol{x} - \boldsymbol{x}_i) \tag{28}$$

where $\boldsymbol{I}_i = q_i \boldsymbol{v}_i$

(II) The author assume that the electromagnetic field satisfy superposition principle, In last section we have said the superposition principle has the problem but we have not really show what the big problem is, now let us first assume the superposition principle is OK, and later see what will happen.

$$\boldsymbol{E}(\boldsymbol{x}, t) = \sum_{i=1}^{N} \boldsymbol{E}(\boldsymbol{x}_i, \boldsymbol{x}, t) \tag{29}$$

$$\boldsymbol{H}(\boldsymbol{x}, t) = \sum_{i=1}^{N} \boldsymbol{H}(\boldsymbol{x}_i, \boldsymbol{x}, t) \tag{30}$$

We often write

$$\boldsymbol{E}_i = \boldsymbol{E}(\boldsymbol{x}_i, \boldsymbol{x}, t) \tag{31}$$

$$\boldsymbol{H}_i = \boldsymbol{H}(\boldsymbol{x}_i, \boldsymbol{x}, t) \tag{32}$$

$$\boldsymbol{J_i} = \boldsymbol{\rho v_i} \delta(\boldsymbol{x} - \boldsymbol{x}_i) = \boldsymbol{I}_i \delta(\boldsymbol{x} - \boldsymbol{x}_i) \tag{33}$$

(III) The author assume that there are N charges in the empty space. We assume the charges satisfy energy conservation,

$$\int_{t=-\infty}^{\infty} \sum_{i=1}^{N} W_i = 0 \tag{34}$$

where

$$W_i = \sum_{j=1, j\neq i}^{N} \boldsymbol{E}_j \cdot J_i \tag{35}$$

is power on i's charge. The i-th charge can only obtained the force from $N-1$ other charges. Hence we have,

$$\int_{t=-\infty}^{\infty} \sum_{i=1}^{N} \sum_{j=1, j\neq i}^{N} \boldsymbol{E}_j \cdot J_i = 0 \tag{36}$$

Condition (III) has accept the thought of absorber theory and action-at-a-distance principle. That means that our universe has only N charges, the radiation and force that can all be seen as action and reaction, which are only take place at these N charges. No any radiation will go to outside of this N charge system.

This condition tell us the work is done for all J_i are not changed, and hence the energy is conserved for this N charge system. We know for the class electric electromagnetic field theory, the condition (I) and (II) is enough to get a solution. If the condition (III) is added, there is possible to have conflict. One of the author's goal is in case there is conflict, we can properly adjust so that the conflict can be eliminated.

We have said the superposition principle has some problem, but in the beginning, we still started from it. In the future if it has problem we will make correction in that time.

3.2 The Maxwell equation for N charges

Together with the Maxwell equation Eq.(24,25) and the superposition principle Eq.(29,30) we have,

$$\nabla \times \boldsymbol{E}(\boldsymbol{x}, t) = -\frac{\partial B(\boldsymbol{x}, t)}{\partial t} \tag{37}$$

$$\nabla \times \boldsymbol{H}(\boldsymbol{x}, t) = \boldsymbol{J} + \frac{\partial D(\boldsymbol{x}, t)}{\partial t} \tag{38}$$

3.3 The Poynting theorem of N charges

From the Maxwell equation we can derive the Poynting theorem[14], which is give as following,

$$-\oiint_{\Gamma}(\boldsymbol{E}\times\boldsymbol{H})\cdot\hat{n}d\Gamma=\iiint_{V}(\boldsymbol{E}\cdot\boldsymbol{J}+\boldsymbol{E}\cdot\partial\boldsymbol{D}+\boldsymbol{H}\cdot\partial\boldsymbol{B})dV \tag{39}$$

the electromagnetic field of N charges can be obtained by the superposition principle Eq.(9),

$$\boldsymbol{E}=\sum_{i=1}^{N}\boldsymbol{E}(\boldsymbol{x}_i,\boldsymbol{x}) \tag{40}$$

$$\boldsymbol{H}=\sum_{i=1}^{N}\boldsymbol{H}(\boldsymbol{x}_i,\boldsymbol{x}) \tag{41}$$

$$\boldsymbol{D}=\sum_{i=1}^{N}\boldsymbol{D}(\boldsymbol{x}_i,\boldsymbol{x}) \tag{42}$$

$$\boldsymbol{B}=\sum_{i=1}^{N}\boldsymbol{B}(\boldsymbol{x}_i,\boldsymbol{x}) \tag{43}$$

Hence we have,

$$-\oiint_{\Gamma}(\sum_{i=1}^{N}\sum_{j=1}^{N}\boldsymbol{E}(\boldsymbol{x}_i,\boldsymbol{x})\times\boldsymbol{H}(\boldsymbol{x}_j,\boldsymbol{x}))\cdot\hat{n}d\Gamma=\sum_{i=1}^{N}\sum_{j=1}^{N}\boldsymbol{I}_i\cdot\boldsymbol{E}(\boldsymbol{x}_j,\boldsymbol{x}_i)$$

$$+\iiint_{V}\sum_{i=1}^{N}\sum_{j=1}^{N}(\boldsymbol{E}(\boldsymbol{x}_i,\boldsymbol{x})\cdot\partial\boldsymbol{D}(\boldsymbol{x}_j,\boldsymbol{x})+\boldsymbol{H}(\boldsymbol{x}_i,\boldsymbol{x})\cdot\partial\boldsymbol{B}(\boldsymbol{x}_j,\boldsymbol{x}))dV \tag{44}$$

In the above second item, we have considered that,

$$\iiint_{V}(\boldsymbol{J}_i\cdot\boldsymbol{E}(\boldsymbol{x}_i,\boldsymbol{x}))dV=\iiint_{V}(\boldsymbol{I}_i\delta(\boldsymbol{x}-\boldsymbol{x}_i)\cdot\boldsymbol{E}(\boldsymbol{x}_j,\boldsymbol{x}))dV=\boldsymbol{I}_i\cdot\boldsymbol{E}(\boldsymbol{x}_j,\boldsymbol{x}_i) \tag{45}$$

In the above formula we have considered Eq.(14, 15, 16).

3.4 The bug in Poynting theorem

We obtain Eq.(22) in the subsection 2.2, and we obtain Eq.(44) in last subsection. Inside the two formulas all have a items,

$$\boldsymbol{I}_i\cdot\boldsymbol{E}(\boldsymbol{x}_j,\boldsymbol{x}_i) \tag{46}$$

But the summations before it are,

$$\sum_{i=1}^{N}\sum_{j=1}^{N} \tag{47}$$

Which is different from energy conservation condition Eq.(23). $\sum_{i=1}^{N}\sum_{j=1}^{N}\boldsymbol{I}_i\cdot\boldsymbol{E}(\boldsymbol{x}_j,\boldsymbol{x}_i)$ expresses also the interaction power of all charges in the system. From this comparison to the energy conservation condition Eq.(36), this author believe the Poynting theorem has overestimated the power of all charges in the system.

Our goal is to derive the energy conservation condition Eq.(36). In the later we can prove that the energy conservation condition con be easily derived if we using the summation in Eq.(23) to replace the summation of Eq.(47) in Eq.(44), we obtain,

$$-\oiint_{\Gamma}(\sum_{i=1}^{N}\sum_{j=1,j\neq i}^{N}\boldsymbol{E}_i\times\boldsymbol{H}_j)\cdot\hat{n}d\Gamma$$

$$=\iiint_{V}\sum_{i=1}^{N}\sum_{j=1,j\neq i}^{N}(\boldsymbol{E}_i\cdot\boldsymbol{J}_j)dV$$

$$\iiint_{V}\sum_{i=1}^{N}\sum_{j=1,j\neq i}^{N}(\boldsymbol{E}_i\cdot\partial\boldsymbol{D}_j+\boldsymbol{H}_i\cdot\partial\boldsymbol{B}_j)dV \tag{48}$$

In the above formula we have written $\boldsymbol{E}(\boldsymbol{x}_i,\boldsymbol{x})$ as $\boldsymbol{E}_i$ and we have considered Eq.(45) and replaced $\boldsymbol{I}_i$ by $\boldsymbol{J}_i$ within the integral.

The above formula Eq.(48) is the rest items of the Poynting theorem Eq.(44), if all self-items are taken away. The all self items are as following,

$$-\oiint_{\Gamma}\sum_{i=1}^{N}\boldsymbol{E}_i\times\boldsymbol{H}_i)\cdot\hat{n}d\Gamma=\iiint_{V}\sum_{i=1}^{N}(\boldsymbol{E}_i\cdot\boldsymbol{J}_i)dV$$

$$\iiint_{V}\sum_{i=1}^{N}(\boldsymbol{E}_i\cdot\partial\boldsymbol{D}_i+\boldsymbol{H}_i\cdot\partial\boldsymbol{B}_i)dV \tag{49}$$

That means we have actually let,

$$\iiint_{V}(\boldsymbol{E}_i\cdot\boldsymbol{J}_i)dV=0 \tag{50}$$

$$\oiint_{\Gamma}(\boldsymbol{E}_i\times\boldsymbol{H}_i)\cdot\hat{n}d\Gamma=0 \tag{51}$$

$$\iiint_{V}(\boldsymbol{E}_i\cdot\partial\boldsymbol{D}_i+\boldsymbol{H}_i\cdot\partial\boldsymbol{B}_i)dV=0 \tag{52}$$

Substitute the above 3 formulas to Poynting theorem of N charges Eq.(44) we can obtained Eq.(48).

4 The mutual energy principle

According to the above discussion, we introduce the the self-energy condition and the mutual energy principle:

4.1 The self-energy conditions

$$-\oint\!\!\!\oint_{\Gamma}(\sum_{i=1}^{N}\boldsymbol{E}_i\times\boldsymbol{H}_i)\cdot\hat{n}d\Gamma$$

$$=\iiint_V(\sum_{i=1}^{N}(\boldsymbol{E}_i\cdot\boldsymbol{J}_i)dV+\iiint_V(\sum_{i=1}^{N}(\boldsymbol{E}_i\cdot\partial\boldsymbol{D}_i+\boldsymbol{H}_i\cdot\partial\boldsymbol{B}_i)dV=0 \tag{53}$$

The above self energy condition tell us that all self-energy items are zero,

(1) Self-power:

$$\iiint_V(\boldsymbol{E}_i\cdot\boldsymbol{J}_i)dV=0 \tag{54}$$

(2) Self-energy increase in the space:

$$\iiint_V(\boldsymbol{E}_i\cdot\partial\boldsymbol{D}_i+\boldsymbol{H}_i\cdot\partial\boldsymbol{B}_i)dV=0 \tag{55}$$

(3) Self-energy flow (this is corresponding to the Poynting vector $\boldsymbol{E}_i\times\boldsymbol{H}_i$)

$$\oint\!\!\!\oint_{\Gamma}(\boldsymbol{E}_i\times\boldsymbol{H}_i)\cdot\hat{n}d\Gamma=0 \tag{56}$$

The self-energy items all vanishes, is the results of our guess from the following reason.

(1) If the self-energy flow doesn't vanish, the energy will spread to the entail empty space. This energy will leave our universe, that is very strange.

(2) If the self-energy flow doesn't leaving our universe, the concept wave function collapse should be introduced. However we have know the energy can be transferred by the mutual energy flow (which will be discuss in later section), we will try to avoid the wave function collapse, since wave function collapse process cannot be described by any formulas.

(3) If self-power

$$\sum_{i=1}^{N}\iiint_V(\boldsymbol{E}_i\cdot\boldsymbol{J}_i)dV\neq 0 \tag{57}$$

that means the self-field of the charge can produce a force to the current of its charge $\boldsymbol{J}_i$. This do not satisfy the Newton's mechanics law that any object cannot apply a force to itself. A few physicists believe in the electromagnetic field theory, the mechanics law is allowed to be broken. However this author fell this mechanic law should still be insisted.

(4) Absorber theory[1, 2] and a-action-at-distance[28, 10, 30] all do not support the idea the force of a charge can apply a force to itself.

(5) In last section we have found the Poyting theorem of N charges has a over estimation of the power of the system also suggested that the self-energy flow should vanish.

We will discuss this self-condition more details in later sections. We do not claim this self-energy condition is all OK, we will correct it if some thing still does not satisfy. Now let us just accept it. This will be the starting point of the author's new electromagnetic field theory.

4.2 Comparison of the Poynting theorem and the mutual energy formula

In the following we compare the Poynting theorem Eq.(44) and the mutual energy formula Eq.(48) and see which is more meaningful. We can write the left side of Eq.(48) as,

$$\oiint_{\Gamma}(\sum_{i=1}^{N}\sum_{j=1,j\neq i}^{N}\boldsymbol{E}_i\times\boldsymbol{H}_j)\cdot\hat{n}d\Gamma=0 \qquad (58)$$

which is the power sends to outside of our space if Γ is big sphere contains our universe, it is the flux of the energy flow send to outside of the universe, it should vanish. If there is only N charge in a empty space, there should no energy flow go outside according to the action-at-a-distance principle. We have known from the mutual energy theorem[19, 24] if photon's field either retarded field for the emitter or advanced field from absorber, the mutual energy flow vanishes on the big sphere Γ. In the mutual energy theorem there is only two charges, the emitter and the absorber. But that result can be widen to N charges, if all two charges can be made as a pair. Hence the left side of Eq.(48) should vanishes.

The second term in the right side of Eq.(48) is the system energy in the space. If started from some time there is no action or reaction to a end time there is also no action and reaction. The integral of this energy vanishes, i.e.,

$$\int_{t=-\infty}^{\infty}\iiint_{V}(\sum_{i=1}^{N}\sum_{j=1,j\neq i}^{N}(\boldsymbol{E}_i\cdot\partial\boldsymbol{D}_j+\boldsymbol{H}_i\cdot\partial\boldsymbol{B}_j)dVdt=0 \qquad (59)$$

Substitute Eq.(58 and 59) to Eq.(48), we have the last term,

$$\int_{t=-\infty}^{\infty}\iiint_{V}\sum_{i=1}^{N}\sum_{j=1,j\neq i}^{N}(\boldsymbol{E}_i\cdot\boldsymbol{J}_j)dVdt=0 \qquad (60)$$

These term also vanish. The left side of above formula is the power we have obtained it at Eq.(22). The above formula tell us for the whole system, all energy is conserved. There is no any energy sends to outside of our universe (if our universe is composed as N charges). Hence, this is a corrected formula. The above formula vanishes means that Eq.(48) satisfies the action-at-a-distance theory. The whole power of the system with all charges are same as the subsection 2.2. It is much meaningful comparing to the Poynting theorem Eq.(44) in which it has the items,

$$\iiint\limits_V (\boldsymbol{E}_i \cdot \boldsymbol{J}_i) dV = \iiint\limits_V (\boldsymbol{E}(\boldsymbol{x}_i, \boldsymbol{x}) \cdot \boldsymbol{J}_i(\boldsymbol{x})) dV = \infty \tag{61}$$

Since if the charge is a point, there is $\boldsymbol{E}_i = \boldsymbol{E}(\boldsymbol{x}_i, \boldsymbol{x}) \to \infty$, if $\boldsymbol{x} \to \boldsymbol{x}_i$. It also has the items

$$\oiint\limits_\Gamma (\boldsymbol{E}_i \times \boldsymbol{H}_i) \cdot \hat{n} d\Gamma \neq 0 \tag{62}$$

The system always has some energy go to outside even where is empty space without other absorbers to absorb the energy. This is not suitable to the argument of Tetrode that if sun in empty space it should not send light out, because there is no any absorber to receive the light!

If the system is our universe, it must be opaque to receive all energy, otherwise our universe will have a continuous loss of the energy. Up to now there is no any testimony that our universe is opaque. It is very strange. The following items in Poynting theorem,

$$\sum_{j=1}^{N} \sum_{i=1}^{N} (\boldsymbol{E}_i \cdot \boldsymbol{J}_j) \tag{63}$$

is not the power of the whole system of N charges. It is over estimated the power of a system with N charges! The problem of the Poynting theorem is the cause that a re-normalization process has to be done for quantum physics. This is a bug of the Poynting theorem with N charges. Poynting theorem is derived from MCMEQ. MCMEQ is derived from SCMEQ by apply the principle of superimposition principle. The bug in Poynting theorem is also a bug in either in the superimposition principle or in SCMEQ or in both. We have not found any problem with mutual energy formula Eq.(48).

In this subsection, the Eq.(58,59,60) are not proved strictly, we will comeback later to discuss this again.

4.3 The mutual energy principle

In the electromagnetic field, from the low frequency bound for example wireless wave to the high frequency bound for example light or x-ray, there is the following mutual energy principle,

$$-\oiint\limits_\Gamma \left(\sum_{i=1}^{N} \sum_{j=1, j\neq i}^{N} \boldsymbol{E}_i \times \boldsymbol{H}_j\right) \cdot \hat{n} d\Gamma$$

$$= \iiint_V \sum_{i=1}^{N} \sum_{j=1,j\neq i}^{N} (\boldsymbol{E}_i \cdot \boldsymbol{J}_j) dV$$

$$\iiint_V \sum_{i=1}^{N} \sum_{j=1,j\neq i}^{N} (\boldsymbol{E}_i \cdot \partial \boldsymbol{D}_j + \boldsymbol{H}_i \cdot \partial \boldsymbol{B}_j) dV \tag{64}$$

This principle is obtained from the N charge Poynting theorem Eq.(44) by using the self-energy condition Eq.(54,55,56). This means that this principle does not conflict with the SCMEQ and the superposition principle. This principle does also not conflict with self-energy condition Eq.(54,55,56)

We will prove in the later section that we can derive the energy conservation condition Eq.(34) from this mutual energy principle. The principle can also be written as,

$$- \oiint_\Gamma (\sum_{i=1}^{N} \sum_{j=1}^{j<i} (\boldsymbol{E}_i \times \boldsymbol{H}_j + \boldsymbol{E}_j \times \boldsymbol{H}_i) \cdot \hat{n} d\Gamma$$

$$= \iiint_V \sum_{i=1}^{N} \sum_{j=1}^{j<i} (\boldsymbol{E}_i \cdot \boldsymbol{J}_j + \boldsymbol{E}_j \cdot \boldsymbol{J}_i) dV$$

$$= \iiint_V \sum_{i=1}^{N} \sum_{j=1}^{j<i} (\boldsymbol{E}_i \cdot \partial \boldsymbol{D}_j + \boldsymbol{H}_i \cdot \partial \boldsymbol{B}_j + \boldsymbol{E}_j \cdot \partial \boldsymbol{D}_i + \boldsymbol{H}_j \cdot \partial \boldsymbol{B}_i) dV \tag{65}$$

Corresponding differential format of the above principle

$$- \sum_{i=1}^{N} \sum_{j=1}^{j<i} \nabla \cdot (\boldsymbol{E}_i \times \boldsymbol{H}_j + \boldsymbol{E}_j \times \boldsymbol{H}_i)$$

$$= \sum_{i=1}^{N} \sum_{j=1}^{j<i} (\boldsymbol{E}_i \cdot \boldsymbol{J}_j + \boldsymbol{E}_j \cdot \boldsymbol{J}_i)$$

$$= \sum_{i=1}^{N} \sum_{j=1}^{j<i} (\boldsymbol{E}_i \cdot \partial \boldsymbol{D}_j + \boldsymbol{H}_i \cdot \partial \boldsymbol{B}_j + \boldsymbol{E}_j \cdot \partial \boldsymbol{D}_i + \boldsymbol{H}_j \cdot \partial \boldsymbol{B}_i) \tag{66}$$

A important situation is there are only two charges in the system, the other charge do not involved. One charge is the emitter, another charge is the absorber, the above mutual energy principle for the two charge can be written as following,

$$- \oiint_\Gamma (\boldsymbol{E}_1 \times \boldsymbol{H}_2 + \boldsymbol{E}_2 \times \boldsymbol{H}_1) \cdot \hat{n} d\Gamma = \iiint_V (\boldsymbol{E}_2 \cdot \boldsymbol{J}_1 + \boldsymbol{E}_1 \cdot \boldsymbol{J}_2) dV$$

$$+\iiint_V (\boldsymbol{E}_1 \cdot \partial \boldsymbol{D}_2 + \boldsymbol{E}_2 \cdot \partial \boldsymbol{D}_1 + \boldsymbol{H}_1 \cdot \partial \boldsymbol{B}_2 + \boldsymbol{H}_2 \cdot \partial \boldsymbol{B}_1) dV \tag{67}$$

or in the differential situation,

$$-\nabla \cdot (\boldsymbol{E}_1 \times \boldsymbol{H}_2 + \boldsymbol{E}_2 \times \boldsymbol{H}_1) = \boldsymbol{E}_2 \cdot \boldsymbol{J}_1 + \boldsymbol{E}_1 \cdot \boldsymbol{J}_2$$

$$+\boldsymbol{E}_1 \cdot \partial \boldsymbol{D}_2 + \boldsymbol{E}_2 \cdot \partial \boldsymbol{D}_1 + \boldsymbol{H}_1 \cdot \partial \boldsymbol{B}_2 + \boldsymbol{H}_2 \cdot \partial \boldsymbol{B}_1 \tag{68}$$

This situation is the case of a normal photon. A photon is a two-charge system. One charge is the emitter, another charge is the absorber. Assume the emitter randomly sends retarded wave out and the absorber randomly sends the advanced wave out.

From now we will treat the above mutual energy principle as an axiom of electromagnetic field theory.

5 There must be a pair of SCMEQ

In this section we will try to prove that SCMEQ is still OK. The bug is in the superposition principle.

5.1 SCMEQ is still correct, but the advanced wave cannot be avoided

In the above we have found that the superposition principle and SCMEQ have conflict with energy conservation condition. This conflict led to the self-condition Eq.(50, 51, 52). Since having this conflict, we have at least question the 3 conditions in of our starting points in the subsection 3.3. Since the energy conservation has to be accept. SCMEQ and the principle of superposition have to be questioned. Hence we have to give up these two conditions: I. SCMEQ and II. the superposition principle at least temperately.

Since we have to give up this two (I) SCMEQ and (II) the superposition principle at least temperately, we will use the mutual energy principle in last subsection 4.3 to replace the (I) SCMEQ and (II) the superposition principle. In the above only 2 charges situation, we can try to find the solution for the above mutual energy principle. In order to do so the above equation Eq.(68) is rewritten by using the following vector equation,

$$\nabla \cdot (\boldsymbol{E}_1 \times \boldsymbol{H}_2) = \nabla \times \boldsymbol{E}_1 \cdot \boldsymbol{H}_2 - \nabla \times \boldsymbol{H}_2 \cdot \boldsymbol{E}_1 \tag{69}$$

We obtain,

$$-(\nabla \times \boldsymbol{E}_1 \cdot \boldsymbol{H}_2 - \nabla \times \boldsymbol{H}_2 \cdot \boldsymbol{E}_1) - (\nabla \times \boldsymbol{E}_2 \cdot \boldsymbol{H}_1 - \nabla \times \boldsymbol{H}_1 \cdot \boldsymbol{E}_2)$$

$$= \boldsymbol{E}_1 \cdot \boldsymbol{J}_2 + \boldsymbol{E}_2 \cdot \boldsymbol{J}_1 +$$
$$+\boldsymbol{E}_1 \cdot \partial \boldsymbol{D}_2 + \boldsymbol{H}_1 \cdot \partial \boldsymbol{B}_2 + \boldsymbol{E}_2 \cdot \partial \boldsymbol{D}_1 + \boldsymbol{H}_2 \cdot \partial \boldsymbol{B}_1 \tag{70}$$

or it is further rewritten as,

$$-(\nabla \times \boldsymbol{E}_1 + \partial \boldsymbol{B}_1) \cdot \boldsymbol{H}_2 + (\nabla \times \boldsymbol{H}_2 - \boldsymbol{J}_2 - \partial \boldsymbol{D}_2) \cdot \boldsymbol{E}_1$$

$$-(\nabla \times \boldsymbol{E}_2 + \partial \boldsymbol{B}_2) \cdot \boldsymbol{H}_1 + (\nabla \times \boldsymbol{H}_1 - \boldsymbol{J}_1 - \partial \boldsymbol{D}_1) \cdot \boldsymbol{E}_2 = 0 \tag{71}$$

Let us consider a spatial situation, the first charge did not move and hence does not send any radiation, we can Assume $\boldsymbol{J}_1 \equiv 0$, if $\boldsymbol{E}_1 \equiv 0$, $\boldsymbol{H}_1 \equiv 0$, then

$$(\nabla \times \boldsymbol{E}_1 + \partial \boldsymbol{B}_1) = 0 \tag{72}$$

$$(\nabla \times \boldsymbol{H}_1 - \boldsymbol{J}_1 - \partial \boldsymbol{D}_1) = 0 \tag{73}$$

and substitute all these to the above formula Eq.(71) we obtain,

$$\nabla \times \boldsymbol{H}_2 - \boldsymbol{J}_2 - \partial \boldsymbol{D}_2 < \infty \tag{74}$$

$$\nabla \times \boldsymbol{E}_2 + \partial \boldsymbol{B}_2 < \infty \tag{75}$$

This give to a solution

$$\boldsymbol{E}_2 = anything < \infty \tag{76}$$

$$\boldsymbol{H}_2 = anything < \infty \tag{77}$$

This is not a accept solution. Hence, this kind solution must be given up. Similarly, if $\boldsymbol{J}_2 \equiv 0$, if $\boldsymbol{E}_2 \equiv 0$, $\boldsymbol{H}_2 \equiv 0$, we can obtain,

$$\boldsymbol{E}_1 = anything < \infty \tag{78}$$

$$\boldsymbol{H}_1 = anything < \infty \tag{79}$$

this kind solution must be given up. This means that, the mutual energy principle do not allow there is only one charge to have a accept nonzero solution. The single charge does not have any radiation all the time.

This means that, the field $\xi_1 = [\boldsymbol{E}_1, \boldsymbol{H}_1]$,$\xi_2 = [\boldsymbol{E}_2, \boldsymbol{H}_2]$ must nonzero in simultaneously. In this situation we obtain from the mutual energy principle Eq.(71),

$$\begin{cases} \nabla \times \boldsymbol{E}_1 + \partial \boldsymbol{B}_1 = 0 \\ \nabla \times \boldsymbol{H}_1 - \boldsymbol{J}_1 - \partial \boldsymbol{D}_1 = 0 \end{cases} \tag{80}$$

$$\begin{cases} \nabla \times \boldsymbol{E}_2 + \partial \boldsymbol{B}_2 = 0 \\ \nabla \times \boldsymbol{H}_2 - \boldsymbol{J}_2 - \partial \boldsymbol{D}_2 = 0 \end{cases} \tag{81}$$

This is two SCMEQ. Hence the mutual energy principle require that SCMEQ must also work and the two fields must be nonzero simultaneously.

Since we are study the photon which is a very short time phenomenon, if the two fields nonzero simultaneously that means the two fields must be synchronized. Here the word "synchronized" means two events must happen concurrently.

We can prove that if the two sources $\boldsymbol{J}_1 \neq 0$, $\boldsymbol{J}_2 \neq 0$ separately a distance, only when the two fields $\xi_1 = [\boldsymbol{E}_1, \boldsymbol{H}_1]$,$\xi_2 = [\boldsymbol{E}_2, \boldsymbol{H}_2]$ one is retarded wave and another one is advanced wave, it is possible that the two fields ξ_1 and ξ_2 to be synchronized. For example, when the retarded field ξ_1 reaches the position of $\boldsymbol{J}_2$, if $\boldsymbol{J}_2$ send the advanced field ξ_2. In this time ξ_1 and ξ_2 nonzero in the same time. When the advanced wave ξ_2 reach the $\boldsymbol{J}_1$ at the same time as the retarded field ξ_1 is sent out. Hence ξ_1 and ξ_2 are also synchronized at the time $\boldsymbol{J}_1$ sent the retarded wave.

Otherwise, if both $\xi_1 = [\boldsymbol{E}_1, \boldsymbol{H}_1]$,$\xi_2 = [\boldsymbol{E}_2, \boldsymbol{H}_2]$ are retarded wave or both advanced waves, it is not possible to them to be synchronized both in both place in the same time when the wave is sent out and when the wave is received. If there are two retarded waves and if it is synchronized in the place $\boldsymbol{J}_1$, that means the field $\boldsymbol{J}_2$ send a wave ξ_2 before and when the wave ξ_2 is received by $\boldsymbol{J}_1$, $\boldsymbol{J}_1$ will send a wave ξ_1 to J_2, when this wave ξ_1 reached the $\boldsymbol{J}_2$, the events happened after $\boldsymbol{J}_2$ sent the wave ξ_2. Hence at the place of J_2 the two waves cannot be reached in the same time. The two waves can only be synchronized in one place, not both emitter and absorber. For a retarded wave and an advanced wave it is possible to be synchronized in the whole road between the emitter and the absorber.

We have said that since there are conflict between SCMEQ, superposition principle and the energy conservation condition we have temperately give up the both SCMEQ and superposition principle as axioms of the electromagnetic field theory. We use the mutual energy principle as the axiom of the electromagnetic field theory. Now from the mutual energy principle we find that SCMEQ still correct at least some time. However there is the important difference. Originally SCMEQ can be established for single charge. Single charge can send retarded wave or advanced wave. Now there must be two charges one sends the retarded wave and the other sends advanced wave. The charge sending retarded wave is defined as emitter. The charge sending advanced wave is defined as absorber. It required that the two waves: the retarded wave and the advanced wave must be synchronized.

In other electromagnetic theory, it is always to ask whether or not that the advanced wave is accept or not. In this author's theory that advanced wave can not be avoided.

It must notice that we are looking the solutions $\zeta_1 = [\boldsymbol{E}_1, \boldsymbol{H}_1, J_1]$, $\zeta_2 = [\boldsymbol{E}_2, \boldsymbol{H}_2, J_2]$ nonzero simultaneously. Here we use ζ to express fields together with the source and ξ to express only the fields. In the above discussion, if $\xi_1 = [\boldsymbol{E}_1, \boldsymbol{H}_1] \equiv 0$, $\xi_2 = [\boldsymbol{E}_2, \boldsymbol{H}_2] \neq 0$, this is not a physical solution of the mutual energy principle and which is not what we are looking for. However we if $\xi_1 = [\boldsymbol{E}_1, \boldsymbol{H}_1] \equiv 0$, $\xi_2 = [\boldsymbol{E}_2, \boldsymbol{H}_2] \neq 0$ and still satisfy the above SCMEQ

Eq.(81), we will say that the $\xi_2 = [\boldsymbol{E}_2, \boldsymbol{H}_2] \neq 0$ is a probability wave. The solution $\xi_2 = [\boldsymbol{E}_2, \boldsymbol{H}_2] \neq 0$ is not exist as physics solution but it still can be a mathematical solution. Vice versa, $\xi_2 = [\boldsymbol{E}_2, \boldsymbol{H}_2] \equiv 0$, $\xi_1 = [\boldsymbol{E}_1, \boldsymbol{H}_1] \neq 0$ and satisfy SCMEQ Eq.(80) can be seen as a mathematical solution with the interpretation of probability. This way we have offers a very good explanation about the probability interpretation about SCMEQ. This means if we take the mutual energy principle as axiom of electromagnetic field theory, very naturally obtained that the solution of SCMEQ, which is a probability wave. This also shows the advantage that take the mutual energy formula as the axiom for the electromagnetic theory than SCMEQ. A probability wave is corresponding to the probability wave function in quantum mechanics.

If the mutual energy principle is satisfied, it is true there exist a real physical energy flow: the mutual energy flow which is the energy of the photon. The mutual energy flow will be discussed more details in a later section of this article. If the SCMEQ is satisfied, we still do not know whether there is a energy flow or not depending the wave of this SCMEQ can find a counterpart wave to match it. If a retarded wave finds a counterpart wave which is a advanced wave, this retarded wave become a real wave with energy flow. This means the probability wave have the chance become a real wave.

5.2 The bug is at the superposition principle

Since the SCMEQ and superposition principle conflict with the energy conservation condition. We have said the bug is possible at the ether the SCMEQ or the superposition principle, from last subsection 5.1 we know that SCMEQ is still OK at least with some probability, hence, the bug should be at the superposition principle. We should give up the current superposition principle. In the later section of this article we will update the superposition principle or correct the superposition principle. For this moment we just give up the superposition principle.

6 Energy conservation condition is satisfied

6.1 The energy conservation condition is satisfied

In the subsection 4.2 we have show that the mutual energy principle can satisfied the energy conservation condition, but we have not prove it rigorously.

Now we began to prove that (III) the energy conservation condition in subsection 3.1 can be satisfied. Let us consider the mutual energy principle integral formula of Eq.(67). It can be proved that if Γ is taken as infinite big sphere and If the both fields ξ_1 and ξ_2 one is retarded wave and the other is advanced wave, then there is,

$$\oiint_{\Gamma} (\boldsymbol{E}_1 \times \boldsymbol{H}_2 + \boldsymbol{E}_2 \times \boldsymbol{H}_1) \cdot \hat{n} d\Gamma = 0 \tag{82}$$

Assume the distance between two charge is much smaller than the radius of the infinite big sphere Γ. The advanced wave reach the big sphere in a time of the past. The retarded wave reach the big sphere in a time of the future, the two fields cannot nonzero in the surface of Γsimultaneously. Hence the above integral must be zero. Hence we have,

$$0=\iiint\limits_V(\boldsymbol{E}_1\cdot\boldsymbol{J}_2+\boldsymbol{E}_2\cdot\boldsymbol{J}_1)dV+$$

$$+\iiint\limits_V(\boldsymbol{E}_1\cdot\partial\boldsymbol{D}_2+\boldsymbol{H}_1\cdot\partial\boldsymbol{B}_2+\boldsymbol{E}_2\cdot\partial\boldsymbol{D}_1+\boldsymbol{H}_2\cdot\partial\boldsymbol{B}_1)dV \tag{83}$$

Now considering a time integral, the above formula becomes,

$$0=\int\limits_{-\infty}^{\infty}\iiint\limits_V(\boldsymbol{E}_1\cdot\boldsymbol{J}_2+\boldsymbol{E}_2\cdot\boldsymbol{J}_1)dVdt+$$

$$+\int\limits_{-\infty}^{\infty}\iiint\limits_V(\boldsymbol{E}_1\cdot\partial\boldsymbol{D}_2+\boldsymbol{H}_1\cdot\partial\boldsymbol{B}_2+\boldsymbol{E}_2\cdot\partial\boldsymbol{D}_1+\boldsymbol{H}_2\cdot\partial\boldsymbol{B}_1)dVdt \tag{84}$$

Since,

$$\iiint\limits_V(\boldsymbol{E}_1\cdot\partial\boldsymbol{D}_2+\boldsymbol{H}_1\cdot\partial\boldsymbol{B}_2+\boldsymbol{E}_2\cdot\partial\boldsymbol{D}_1+\boldsymbol{H}_2\cdot\partial\boldsymbol{B}_1)dV$$

$$=\partial(\iiint\limits_V(\epsilon_0\boldsymbol{E}_1\cdot\boldsymbol{E}_2+\mu_0\boldsymbol{H}_1\cdot\boldsymbol{H}_2)dV)$$

$$=\partial U \tag{85}$$

where,

$$U=\iiint\limits_V(\epsilon_0\boldsymbol{E}_1\cdot\boldsymbol{E}_2+\mu_0\boldsymbol{H}_1\cdot\boldsymbol{H}_2)dV \tag{86}$$

We have,

$$\int\limits_{-\infty}^{\infty}\iiint\limits_V(\boldsymbol{E}_1\cdot\partial\boldsymbol{D}_2+\boldsymbol{H}_1\cdot\partial\boldsymbol{B}_2+\boldsymbol{E}_2\cdot\partial\boldsymbol{D}_1+\boldsymbol{H}_2\cdot\partial\boldsymbol{B}_1)dVdt$$

$$=\int\limits_{-\infty}^{\infty}\partial U dt=U(\infty)-U(-\infty)=0 \tag{87}$$

Here $U(-\infty)$ is the electromagnetic energy before the emitter sends the retarded wave. $U(\infty)$ is the electromagnetic energy after the absorber receive the photon.

Hence there is $U(\infty) = U(-\infty)$. Hence, the above formula satisfied. Substitute the above formula to Eq.(84) we obtain,

$$\int_{-\infty}^{\infty} \iiint_V (\boldsymbol{E}_1 \cdot \boldsymbol{J}_2 + \boldsymbol{E}_2 \cdot \boldsymbol{J}_1) dV dt = 0 \tag{88}$$

This formula can be rewritten as following,

$$\int_{-\infty}^{\infty} \sum_{i=1}^{2} \sum_{j=1}^{j<i} \iiint_V (\boldsymbol{E}_i \cdot \boldsymbol{J}_j + \boldsymbol{E}_j \cdot \boldsymbol{J}_i) dV dt = 0 \tag{89}$$

If there are N charges, we can prove that the extended results also correct, which are,

$$\int_{-\infty}^{\infty} \sum_{i=1}^{N} \sum_{j=1}^{j<i} \iiint_V (\boldsymbol{E}_i \cdot \boldsymbol{J}_j + \boldsymbol{E}_j \cdot \boldsymbol{J}_i) dV dt = 0 \tag{90}$$

In case all the charge are paired as a emitter and a absorber. It is possible an emitter is also an absorber in a different time or even in the same time but paired with some other charge. The above formula can be written as

$$\int_{-\infty}^{\infty} \sum_{i=1}^{N} \sum_{j=1, j\neq i}^{N} \iiint_V \boldsymbol{E}_i \cdot \boldsymbol{J}_j dV dt = 0 \tag{91}$$

This is the condition (III) which is the energy conservation condition in subsection 3.1. Up to now we have proved that the energy conservation condition can be derived from the mutual energy principle. Hence the mutual energy principle does not conflict with energy conservation condition. We have also know that the SCMEQ can also be derived from the mutual energy principle. But the derived SCMEQ has big difference compare the original SCMEQ, the original SCMEQ support a physic wave sent from a single charge, now it can only support a probability wave. That means it only OK some time. Only when a retarded wave can find an advanced wave to match, this retarded wave become a real wave.

7 Self-energy principle and the time reversal waves

7.1 SCMEQ conflict with self-energy condition

In the subsection 5.1 we obtains the conclusion that the SCMEQ is still partially correct. It is correct if the retarded wave and the advanced wave is synchronized. In case the SCMEQ is correct, the Poynting theorem for single charge mast also be correct, that means,

$$-\oint\!\!\!\oint_{\Gamma}(\boldsymbol{E}_i\times\boldsymbol{H}_i)\cdot\hat{n}d\Gamma=\iiint_V \boldsymbol{E}_i\cdot\boldsymbol{J}_i dV$$

$$+\iiint_V(\boldsymbol{E}_i\cdot\partial\boldsymbol{D}_i+\boldsymbol{H}_i\cdot\partial\boldsymbol{B}_i)dV \tag{92}$$

and

$$\oint\!\!\!\oint_{\Gamma}(\boldsymbol{E}_i\times\boldsymbol{H}_i)\cdot\hat{n}d\Gamma\neq 0 \tag{93}$$

$$\iiint_V \boldsymbol{E}_i\cdot\boldsymbol{J}_i dV\neq 0 \tag{94}$$

$$\iiint_V(\boldsymbol{E}_i\cdot\partial\boldsymbol{D}_i+\boldsymbol{H}_i\cdot\partial\boldsymbol{B}_i)dV\neq 0 \tag{95}$$

This conflict with the self-energy condition Eq.(54, 55, 56).

From the above discussion we have known that the photon is a system with two charges. One is the emitter another is the absorber. The electromagnetic fields of the two charges both can randomly jump up to high energy level or jump down to the lower energy level. If it is jump down it will send retarded wave. If it is jump up it will send advanced wave. Only when one charge sends retarded wave and another sends the advanced wave in the same time, i.e. the two waves are synchronized, the mutual energy principle can be satisfied. The charge which sends retarded wave is referred as the emitter. The charge which sends the advanced wave is referred as the absorber.

Since the field of the charge still satisfy the SCMEQ, the field of the charge should also satisfies the Poynting theorem, which is conflict to the self-energy condition Eq.(54,55,56). This conflict lead us make the following adjustment to the self-energy condition, which lead us introduce the following self-energy principle.

In the the subsection1.5 the author has mentioned that a photon model has been build in which the author has thought perhaps the self-energy flow is not collapsed to its target but collapse to its source. If a wave collapse to its source it can be described as a time-reversal process. It is clear that this time-reversal process can be applied to solved the conflict above.

7.2 A guess about the time-reversal return of the self energy flow

In above our electron magnetic theory only the mutual energy flow (which will be introduced in next section) is involved. What about the self energy flow? It does not carry any energy according to the self energy condition Eq.(54,55,56) we have obtained. It is a probability wave like in quantum physics said. This is often difficult to be understand. People would like to think the wave is a real wave instead a probability wave. We have from the mutual energy principle obtained that SCMEQ is still OK at least partially, which means the Poynting theorem for single charge is also OK partially. This means that the self-energy flow cannot be zero. Hence, our theory becomes conflict.

The author found that a wave it exist but do not carry energy perhaps can be explained as that the wave is actually sent out with energy but later it is time-reversal returned to its source, the pure effect is that the self energy flow vanishes.

Most electromagnetic engineers believe that the electromagnetic wave especially the retarded wave is a real wave and does not like the wave in quantum mechanics which is probability wave. In this article we have shown that the electromagnetic wave, the retarded wave and the advanced wave do not carry any energy if they are alone. The energy is carried through the mutual energy flow which needs the retarded wave and advanced wave to work together and to have been synchronized. Hence in principle, if there is only one wave for example the retarded wave, it can not transfer the energy. The really transfer energy needs an advanced wave to react to it. Hence, the retarded wave can not be seen as a real wave with energy on itself all the time. It can be interpreted as ability wave or probability wave. If we do not satisfy this result, perhaps we can think the retarded wave is still a real wave carries the energy and transferred the energy in the whole empty space, but if there is no advanced wave to receive it, this retarded wave with energy will be time-reversal returned to its source, i.e the emitter. Hence, the retarded wave time-reversal returns to emitter and the advanced wave time-reversal returns to the absorber if they cannot find a counterpart to be synchronized. This is similar to the transactional process in the bank, if some thing is wrong, the money can not be transferred from bank A to bank B, then the money must be returned to bank A. Energy is same as money, if it can not be transferred from A to B, the energy conservation law do not allow it to disappear in the space. Hence this energy no way to go, and it must time-reversal return to its source. This way it can guarantee the energy of the whole system is still conserved.

We do not assume the time-reversal wave for a retarded wave is a retarded wave, instead we will assume the time-reversal wave is a time reversal process of the retarded wave. It is same we do not assume the time-reversal wave for an advanced wave is an advanced wave, instead we assume the time-reversal wave for advanced wave is a time reversal process of the advanced wave.

The author assume that the emitters can randomly send the retarded waves, and the absorbers can also randomly send the advanced waves. Now these waves are real physical waves. If in the time when the retarded wave sends out, there is just a advanced wave to match it, the energy is transferred through the mutual energy flow from the emitter to the absorber. Otherwise the energy in the retarded wave or in the advanced wave will time-reversal return. The time-reversal wave is a time reversal process, which cannot satisfy by Maxwell equations, but it can satisfy time-reversal Maxwell equations, which will be described as following. Since time reversal processes are very confused to us. In the following, this author will discussed them in extremely detail.

It should be notice even the retarded wave of the emitter and the advanced wave of the absorber are synchronized and there are a mutual energy flow goes from the emitter to the absorber, the self-energy flow needs also to be time-reversal returned. That means the self-energy flow always time-reversal returns no matter the mutual energy flow is produced or not.

Assume $\mathbf{R}$ is a time reversal operator, it is defined as

$$\mathbf{R}[\boldsymbol{E}(t),\boldsymbol{H}(t),\boldsymbol{D}(t),\boldsymbol{B}(t),\boldsymbol{x}(t),t]$$

$$=[\boldsymbol{E}(-t),\boldsymbol{H}(-t),\boldsymbol{D}(-t),\boldsymbol{B}(-t),\boldsymbol{x}(-t),-t] \tag{96}$$

where $\boldsymbol{x}(t)$ is the position of the charge.

The time reversal operator act on the following SCMEQ:

$$\oint \boldsymbol{E}\cdot d\boldsymbol{l}=-\frac{d}{dt}\iint \boldsymbol{B}\cdot\hat{n}dA$$

$$\oint \boldsymbol{H}\cdot d\boldsymbol{l}=\iint \boldsymbol{J}\cdot\hat{n}dA+\frac{d}{dt}\iint \boldsymbol{D}\cdot\hat{n}dA \tag{97}$$

For single charge the above Maxwell equations can be written as integral form,

$$\oint \boldsymbol{E}\cdot d\boldsymbol{l}=-\frac{d}{dt}\iint \boldsymbol{B}\cdot\hat{n}dA \tag{98}$$

$$\oint \boldsymbol{H}\cdot d\boldsymbol{l}=q\frac{d\boldsymbol{x}}{dt}+\frac{d}{dt}\iint \boldsymbol{D}\cdot\hat{n}dA \tag{99}$$

In the above we have considered that,

$$\iint \boldsymbol{J}\cdot\hat{n}dA=q\boldsymbol{v}=q\frac{d\boldsymbol{x(t)}}{dt} \tag{100}$$

where $\boldsymbol{v}$ is the speed vector of the charge. q is the amount of charge. After the time reversal operator, the above equations becomes,

$$\oint \boldsymbol{E}(-t)\cdot d\boldsymbol{l}=-\frac{d}{dt}\iint \boldsymbol{B}(-t)\cdot\hat{n}dA$$

$$\oint \boldsymbol{H}(-t)\cdot d\boldsymbol{l}=q\frac{d\boldsymbol{x}(-t)}{dt}+\frac{d}{dt}\iint \boldsymbol{D}(-t)\cdot\hat{n}dA \tag{101}$$

In the above equation, since we have applied the time reversal operator, the time t is directed in negative direction. t is directed to the past. Rewrite above formula as following,

$$\oint \boldsymbol{E}(-t)\cdot d\boldsymbol{l}=\frac{d}{d(-t)}\iint \boldsymbol{B}(-t)\cdot\hat{n}dA \tag{102}$$

$$\oint \boldsymbol{H}(-t)\cdot d\boldsymbol{l}=-q\frac{d\boldsymbol{x}(-t)}{d(-t)}-\frac{d}{d(-t)}\iint \boldsymbol{D}(-t)\cdot\hat{n}dA \tag{103}$$

assume $\tau = -t$, τ become the normal time. Directs to the future.

$$\oint \boldsymbol{E}(\tau) \cdot d\boldsymbol{l} = \frac{d}{d\tau} \iint \boldsymbol{B}(\tau) \cdot \hat{n} dA \tag{104}$$

$$\oint \boldsymbol{H}(\tau) \cdot d\boldsymbol{l} = -q\frac{d\boldsymbol{x}(\tau)}{d\tau} - \frac{d}{d\tau} \iint \boldsymbol{D}(\tau) \cdot \hat{n} dA \tag{105}$$

Change the time variable τ as t we obtains,

$$\oint \boldsymbol{E}(t) \cdot d\boldsymbol{l} = \frac{d}{dt} \iint \boldsymbol{B}(t) \cdot \hat{n} dA$$

$$\oint \boldsymbol{H}(t) \cdot d\boldsymbol{l} = -q\frac{d\boldsymbol{x}(t)}{dt} - \frac{d}{dt} \iint \boldsymbol{D}(t) \cdot \hat{n} dA \tag{106}$$

Written them as differential equation as following,

$$\nabla \times \boldsymbol{E}(t) = \frac{\partial}{\partial t}\boldsymbol{B}(t)$$

$$\nabla \times \boldsymbol{H}(t) = -\boldsymbol{J}(t) - \frac{\partial}{\partial t}\boldsymbol{D}(t) \tag{107}$$

or

$$\nabla \times \boldsymbol{E} = \partial \boldsymbol{B}$$

$$\nabla \times \boldsymbol{H} = -\boldsymbol{J} - \partial \boldsymbol{D} \tag{108}$$

Since the above equation is not Maxwell equations, we cannot call this time-reversal return field as electromagnetic field. We will use another symbol to describe them.

$$\nabla \times \boldsymbol{E}' = \partial \boldsymbol{B}'$$

$$\nabla \times \boldsymbol{H}' = -\boldsymbol{J}' - \partial \boldsymbol{D}' \tag{109}$$

$[\boldsymbol{E}', \boldsymbol{H}', \boldsymbol{D}', \boldsymbol{B}']$ are the time-reversal fields. which is not a normal electromagnetically field. $\boldsymbol{J}'$ is time-reversal current density. $\boldsymbol{J}'$ is normal current density. But $\boldsymbol{J}'$ is not equal to $\boldsymbol{J}$. $\boldsymbol{J}'$ can cancel $\boldsymbol{J}$. In that time $\boldsymbol{J}' = -\boldsymbol{J}$. We speak about the the time-reversal field, the time-reversal process, it is not a returning process. The returning process for retarded wave is still a retarded wave. This time-reversal process for a retarded wave is some kind of advanced wave (actually it is also not advanced wave, the advanced wave is sent a charge from current to the past, the time-reversal wave of a retarded wave sent from infinite big sphere at a future time to the place of the charge at the current time). This time-reversal wave has the power thoroughly cancel all the original wave, even without a history spoor.

To the other two Maxwell equations which are

$$\nabla \cdot \boldsymbol{D}(t) = \rho(t) \tag{110}$$

$$\nabla \cdot \boldsymbol{B}(t) = 0 \tag{111}$$

after the time reverse transform they become,

$$\nabla \cdot \boldsymbol{D}(-t) = \rho(-t) \tag{112}$$

$$\nabla \cdot \boldsymbol{B}(-t) = 0 \tag{113}$$

After substitute $-t = \tau$

$$\nabla \cdot \boldsymbol{D}(\tau) = \rho(\tau) \tag{114}$$

$$\nabla \cdot \boldsymbol{B}(\tau) = 0 \tag{115}$$

Since the two equations are not the Maxwell equation we change them to use different variables, we also change the variable τ as t,

$$\nabla \cdot \boldsymbol{D'}(t) = \rho'(t) \tag{116}$$

$$\nabla \cdot \boldsymbol{B}'(t) = 0 \tag{117}$$

Hence we obtained 4 new Maxwell equations, which are time-reversal Maxwell equations.

7.3 The corresponding Poynting theorem for the time reversal Maxwell equations

Similar to the situation of SCMEQ, the Poynting theorem for single charge can be derived. It is easy to prove that the Poynting theorem for the time-reversal wave can be written as following,

$$\begin{aligned} -\nabla \cdot (\boldsymbol{E}' \times \boldsymbol{H}') &= -(\nabla \times \boldsymbol{E}' \cdot \boldsymbol{H}' - \boldsymbol{E}' \cdot \nabla \times \boldsymbol{H}') \\ &= -\partial \boldsymbol{B}' \cdot \boldsymbol{H}' + \boldsymbol{E}' \cdot (\boldsymbol{J} - \partial \boldsymbol{D}') \\ &= -\boldsymbol{E}' \cdot \boldsymbol{J}' - (\partial \boldsymbol{B}' \cdot \boldsymbol{H}' + \boldsymbol{E}' \cdot \partial \boldsymbol{D}') \end{aligned} \tag{118}$$

Or the corresponding Poynting theorem for the time reversal electromagnetic field is,

$$\begin{aligned} &\oiint_{\Gamma} (\boldsymbol{E}' \times \boldsymbol{H}') \cdot \hat{n} dA \\ &= + \iiint_V \boldsymbol{E}' \cdot \boldsymbol{J}' dV + \iiint_V (\partial \boldsymbol{B}' \cdot \boldsymbol{H}' + \boldsymbol{E}' \cdot \partial \boldsymbol{D}') dV \end{aligned} \tag{119}$$

From this Poynting vector it is clear that the Poynting vector $\boldsymbol{E}' \times \boldsymbol{H}'$ is direct to the inside of the volume V. Here we have assume that the original wave is a retarded wave. $\boldsymbol{E}'$, $\boldsymbol{H}'$ is some kind of advanced wave. It is not really a advanced wave, advanced wave sent from current to the past, but this time-reversal wave of a retarded wave sent from future to the current. The direction of the energy flow of the time-reversal wave of a retarded wave is same as the advanced wave. This direction is at the opposite direction of the retarded wave. We have known, the direction of the Poynting vector $\boldsymbol{E} \times \boldsymbol{H}$ is point to outside of the surface. Hence, the direction of the Poynting vector for $\boldsymbol{E}' \times \boldsymbol{H}'$ directs to the inside of the volume V.

Compare the above formula to the Poynting theorem which is

$$\begin{aligned} -\nabla(\boldsymbol{E} \times \boldsymbol{H}) &= -(\nabla \times \boldsymbol{E} \cdot \boldsymbol{H} - \boldsymbol{E} \cdot \nabla \times \boldsymbol{H}) \\ &+\partial \boldsymbol{B} \cdot \boldsymbol{H} + \boldsymbol{E} \cdot (\boldsymbol{J} + \partial \boldsymbol{D}) \\ &= \boldsymbol{E} \cdot \boldsymbol{J} + (\partial \boldsymbol{B} \cdot \boldsymbol{H} + \boldsymbol{E} \cdot \partial \boldsymbol{D}) \end{aligned} \tag{120}$$

or the Poynting theorem is,

$$\begin{aligned} &- \oint\!\!\!\oint (\boldsymbol{E} \times \boldsymbol{H}) \cdot \hat{n} dA \\ &= \iiint_V \boldsymbol{E} \cdot \boldsymbol{J} dV + \iiint_V (\partial \boldsymbol{B} \cdot \boldsymbol{H} + \boldsymbol{E} \cdot \partial \boldsymbol{D}) dV \end{aligned} \tag{121}$$

If we calculate all the self energy flow includes both two Poynting theorems together. Considering both the retarded wave and the advanced wave and also the corresponding to time-reversal waves, we obtain,

$$\begin{aligned} &\oint\!\!\!\oint_\Gamma (\boldsymbol{E}' \times \boldsymbol{H}') \cdot \hat{n} dA - \oint\!\!\!\oint (\boldsymbol{E} \times \boldsymbol{H}) \cdot \hat{n} dA \\ &= \iiint_V \boldsymbol{E}' \cdot \boldsymbol{J}' dV + \iiint_V \boldsymbol{E} \cdot \boldsymbol{J} dV \\ &+ \iiint_V (\partial \boldsymbol{B}' \cdot \boldsymbol{H}' + \boldsymbol{E}' \cdot \partial \boldsymbol{D}') dV + \iiint_V (\partial \boldsymbol{B} \cdot \boldsymbol{H} + \boldsymbol{E} \cdot \partial \boldsymbol{D}) dV \end{aligned} \tag{122}$$

For the Poynting theorem,
$-\oint\!\!\!\oint_\Gamma (\boldsymbol{E} \times \boldsymbol{H}) \cdot \hat{n} dA$ is the energy flow come to the inside the volume V.
$\iiint_V \boldsymbol{E} \cdot \boldsymbol{J} dV$ the energy changed to become the heat inside the volume V.
$\iiint_V (\partial \boldsymbol{B} \cdot \boldsymbol{H} + \boldsymbol{E} \cdot \partial \boldsymbol{D}) dV$ the energy increase inside the volume V.
For the Poynting theorem corresponding to the time reversal field is,
$\oint\!\!\!\oint (\boldsymbol{E}' \times \boldsymbol{H}') \cdot \hat{n} dA$ The energy flow to the inside of the volume V.
$\iiint_V \boldsymbol{E}' \cdot \boldsymbol{J}' dV$ This is a energy power source which produce energy.
$\iiint_V (\partial \boldsymbol{B}' \cdot \boldsymbol{H}' + \boldsymbol{E}' \cdot \partial \boldsymbol{D}') dV$ is the field energy decrease inside.
It is clear that,

$$|\iiint\limits_V (\partial \boldsymbol{B}' \cdot \boldsymbol{H}' + \boldsymbol{E}' \cdot \partial \boldsymbol{D}')dV| = |\iiint\limits_V (\partial \boldsymbol{B} \cdot \boldsymbol{H} + \boldsymbol{E} \cdot \partial \boldsymbol{D})dV| \tag{123}$$

$$|\iiint\limits_V \boldsymbol{E}' \cdot \boldsymbol{J}' dV| = |\iiint\limits_V \boldsymbol{E} \cdot \boldsymbol{J} dV| \tag{124}$$

$$|\oiint\limits_\Gamma (\boldsymbol{E}' \times \boldsymbol{H}') \cdot \hat{n} dA| = |\oiint (\boldsymbol{E} \times \boldsymbol{H}) \cdot \hat{n} dA| \tag{125}$$

Hence it is clear all of these items just cancel each other, we obtain the following self-energy flow theorem,

$$-\oiint (\boldsymbol{E} \times \boldsymbol{H}) \cdot \hat{n} dA + \oiint (\boldsymbol{E}' \times \boldsymbol{H}') \cdot \hat{n} dA = 0 \tag{126}$$

$$\iiint\limits_V (\partial \boldsymbol{B} \cdot \boldsymbol{H} + \boldsymbol{E} \cdot \partial \boldsymbol{D})dV + \iiint\limits_V (\partial \boldsymbol{B}' \cdot \boldsymbol{H}' + \boldsymbol{E}' \cdot \partial \boldsymbol{D}')dV = 0 \tag{127}$$

$$\iiint\limits_V \boldsymbol{E} \cdot \boldsymbol{J} dV + \iiint\limits_V \boldsymbol{E}' \cdot \boldsymbol{J}' dV = 0 \tag{128}$$

In the above if an item of normal energy increase, the corresponding time-reversal item will decrease.

Hence all the self-energy items are canceled without any history spoor. Hence the self-energy items do not have any contribution for the transferring of the energy. This is the self-energy principle compare to the Eq.(53). Eq.(53) conflict with Maxwell equations and Poynting theorem. Eq.(126,127,128) do not have that problem.

In the above we have described for the situation of the retarded wave. For the advanced wave, the situation is similar, all the items of the advanced wave are balance out with the items of the corresponding time-reversal waves. The advanced wave also does not contribute to the energy transfer.

The the self-energy time-reversal process described with the above, it can be seen as collapse processes, the wave collapse to it's source, either emitter or the absorber. This collapsed process is different to the wave function collapse in quantum mechanics, in which the retarded wave collapse to the absorber. The advanced wave collapse to the emitter. Hence it can be referred as collapse to its target. No one offers a formula to describe the collapse process to the its target. The time reversal wave has not been proved by the experiment, just like the wave function collapse has not been proved in experiment, but it still can be applied to interpret of the light waves. With the concept of time-reversal waves our theory become selfconsistent.

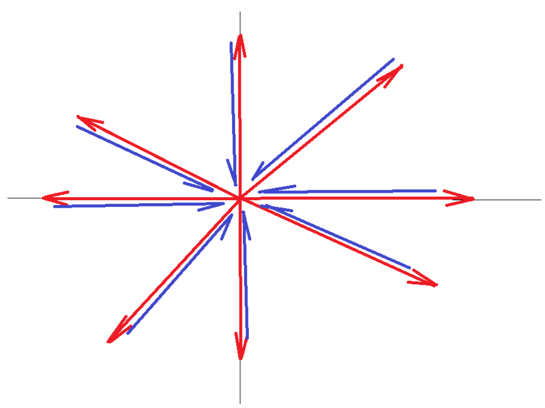

Figure 1: For an emitter, it send retarded wave to the entire empty space. This retarded wave is referred as self-energy flow. No matter the mutual energy flow is produced or not, the self energy flow will time-reversal return to its source, i.e. the emitter. It is same to the advanced wave, the absorber sends the advanced wave to the entire empty space, no matter the mutual energy flows are produced or not, the self-energy flows of the advanced wave has to be time-reversal return to its source which is the absorber.

Hence the interpretation that wave is time-reversal returned with the above time-reversal process is better other interpretation that the wave function collapse. The wave function collapse cannot be described with any formula or equations.

It should be noticed that if the retarded wave is a real wave with energy in space, it must be time-reversal returned if there is no the matched advanced wave. Actually even there is a photon has been sent out, that is only the mutual energy flow, the self-energy flow is still in the space. After the energy transfer process of the photon, the self-energy and the self-energy flow also needs to be time-reversal returned. The self-energy flow help the mutual energy transfer the energy in the space. After the energy transferring process, either the energy is transferred or not, the self-energy flow of the emitter has to time-reversal return to the emitter and the self-energy flow of the advanced wave has to time-reversal return to the absorber.

In the discussion about the mutual energy principle, we do not care the self-energy flow which dos not carry energy in physics. But now we can also assume it carry energy, but the energy time-reversal returns to its source, hence the pure effect just like the self-energy flow does not transfer the energy.

For the retarded wave, the corresponding time-reversal wave is some kind of an advanced wave which can cancel the retarded wave exactly. Here the author said it is a some kind of advanced wave, only consider the time-direction of the energy flow which is same as the advanced wave. However it is not an exact advanced wave. The advanced wave is sent from current time to the past time. The time-reversal wave of a retarded wave send wave from future time back to the current time. The total result of a retarded wave and the time-reversal wave of the retarded looks like the retarded wave never happened, even without a history spoor. For an advanced wave, the corresponding time-reversal wave is some kind of a retarded wave which can cancel the advanced wave exactly. The total result of an advanced wave and its time-reversal wave looks like the advanced wave never happened. See Figure 1 for a retarded wave and its corresponding time-reversal wave, which are balance out or canceled.

7.4 Summary of the 4 different fields

Hence in the author's theory, for a model of a photon there are 4 different fields:

(1) The retarded wave, this wave time-direction is from current time to the future. This wave satisfies SCMEQ. The source of this wave is the emitter.

(2) The advanced wave. The wave time-direction is from the current time to the past. This wave satisfies SCMEQ. The source of this wave is the absorber.

(3) The time-reversal wave of the retarded field, which actually is also some kind of advanced wave. This wave time-direction is from future to the current time. This wave satisfies the time-reversal Maxwell equations.

(4) The time reversal wave of the advanced wave, which is also some kind of the retarded wave. The wave time-direction is from past to current time. This wave satisfies the time reversal Maxwell equations.

There are 4 self-energy flows corresponding to the above 4 waves.

The retarded wave and the advanced wave can interfere each other or superpose together and this superposition produce the mutual energy flow which is the normal mutual energy flow.

The author assume it is possible that another kind of mutual energy flow can be produced, which is the mutual energy flow of the time-reversal wave of the retarded wave and the time-reversal wave of the advanced wave. It can be referred as time-reversal mutual energy flow. The time-reversal mutual energy flow can balance out or cancel the normal mutual energy flow. This will be applied to explain the reason why we cannot receive half photon. Explain why a half photon energy package cannot be established. If the absorber only received half photon, the absorber can return this part of energy to emitter by the time-reversal mutual energy flow.

The energy flow of the time reversal field corresponding to the retarded field can cancel the energy flow of the retarded wave. The energy flow of the time reversal field corresponding to the advanced field can cancel the energy flow of the advanced wave.

Hence, in the author's theory there are 4 waves and 6 energy flows for a photon. Each wave has a energy flow, but there are two additional energy flows which are the mutual energy flow and time-reversal mutual energy flow. This together consist a particle-wave which is a wave with momentum and energy and localized in the space. A photon's particle-wave is not produced with only one wave and with one energy flow, it is consist of 4 waves with 6 energy flows.

7.5 The difference of the time-reversal transform and the conjugate transform

The time-reversal transform can be summarized as

Assume $\mathbf{R}$ is a time reversal operator, it is defined as

$$\mathbf{R}[\boldsymbol{E}(t), \boldsymbol{H}(t), \boldsymbol{D}(t), \boldsymbol{B}(t), \boldsymbol{x}(t), t]$$

$$= [\boldsymbol{E}(-t), \boldsymbol{H}(-t), \boldsymbol{D}(-t), \boldsymbol{B}(-t), -\boldsymbol{J}(-t)] \tag{129}$$

In Frequency domain this can be re-written as

$$\mathbf{R}[\boldsymbol{E}(\omega), \boldsymbol{H}(\omega), \boldsymbol{D}(\omega), \boldsymbol{B}(\omega)]$$

$$= [\boldsymbol{E}^*(\omega), \boldsymbol{H}^*(\omega), \boldsymbol{D}^*(\omega), \boldsymbol{B}^*(\omega), -\boldsymbol{J}^*(\omega)] \tag{130}$$

It should be mentioned here the time-reversal transform $\mathbf{R}$ is differ with the conjugate transform $\mathbf{C}$[11]. The conjugate transform is given by the following,

$$\mathbf{C}[\boldsymbol{E}(t), \boldsymbol{H}(t), \boldsymbol{D}(t), \boldsymbol{B}(t), \boldsymbol{x}(t), t]$$

$$= [\boldsymbol{E}(-t), -\boldsymbol{H}(-t), \boldsymbol{D}(-t), -\boldsymbol{B}(-t), -\boldsymbol{J}(-t)] \tag{131}$$

$$\mathbf{C}[\boldsymbol{E}(\omega),\boldsymbol{H}(\omega),\boldsymbol{D}(\omega),\boldsymbol{B}(\omega)]$$

$$=[\boldsymbol{E}^{*}(\omega),-\boldsymbol{H}^{*}(\omega),\boldsymbol{D}^{*}(\omega),-\boldsymbol{B}^{*}(\omega),-\boldsymbol{J}^{*}(\omega)] \tag{132}$$

The conjugate transform is adjusted time-reversal transform. After this adjustment, the result can satisfy Maxwell equations. Hence the result of time-reversal transform do not satisfy the Maxwell equations, but satisfy the time-reversal Maxwell equations. After the conjugate transform, the result still satisfy Maxwell equations. **C** will change the retarded wave to advanced wave, and change the advanced wave to retarded wave. But **R** will change the the wave either retarded or advanced to the corresponding time-reversal waves. After the operator **R** and **C** the field still physical amount.

As I know there are arguments in internet post about whether inside the time-reversal transform, for the magnetic field should add a minus sign or not. Now we are clear for the magnetic field, it can add or not add a minus sign depending what transform **R** and **C** you like to do. Both are correct. Please notice that in the publications when other author spoke about time-reversal transform, it is often they are talking about conjugate transform. This author introduced a new kind electromagnetic field. Hence need to distinguish these two kind of transforms.

8 Mutual energy theorem and the mutual energy flow

8.1 The mutual energy theorem for photon

Assume $\xi_1 = [\boldsymbol{E}_1, \boldsymbol{H}_1]$ is retarded wave, $\xi_2 = [\boldsymbol{E}_2, \boldsymbol{H}_2]$ are advanced wave. Assume the electromagnetic field waves are only short time impulses. ξ_1 and ξ_2 satisfy Eq(80,81) and are synchronized. The Eq.(88) can be rewritten as,

$$-\int_{-\infty}^{\infty}\iiint_V \boldsymbol{E}_2\cdot\boldsymbol{J}_1 dVdt=\int_{-\infty}^{\infty}\iiint_V \boldsymbol{E}_1\cdot\boldsymbol{J}_2 dVdt \tag{133}$$

This is formula is looks same as W.J. Welch's time domain reciprocity theorem[31]. If in the Fourier domain this formula looks like the original mutual energy theorem of the author[15, 34, 33].

It should be clear here, in here the author has introduce this theorem to the photon situation, the meaning of this formula is different to compare with the original Welch's time-domain reciprocity theorem. In Welch's theorem the source still sends the wave energy to the whole space, there is only a small part of energy send out from transmitting antenna to the receiving antenna. Welch's theorem tell us that the part of energy sent from transmitting antenna to the receiving antenna is equal to the energy received by the receiving antenna. The original Welch's theorem is clear correct and hence it is trivialness. Welch even did not realize the theorem is an energy theorem, hence he call it is a time-domain reciprocity theorem. As a reciprocity theorem it is used to make some calculation in which the two fields $\zeta_1 = [\boldsymbol{E}_1, \boldsymbol{H}_1, \boldsymbol{J}_1]$ and $\zeta_2 = [\boldsymbol{E}_2, \boldsymbol{H}_2, \boldsymbol{J}_2]$ do not need to be all physical field. Usually only one is physical field for example ζ_1, but ζ_2 is a virtual field. Hence if ζ_1 is retarded field, ζ_2 is advanced field, there is no any problem since the advanced field is not a real field, it is only a virtual field used in the reciprocity theorem for some calculation convenience. Hence the advanced wave do not need to be a real wave in the meaning of physics. In contrast, the mutual energy theorem emphasize it is an energy theorem, hence the two fields are all real physical fields.

Another important thing is that the above formula now tell us that all energy sent from the emitter is received by the absorber. The energy sends from the emitter to the whole space (not received by the absorber) is 0. The reason of that is because the new mutual energy theorem is derived from the self-energy principle and the mutual energy principle which guarantees that all the self-energy flow has been canceled with the corresponding time-reversal return self-energy waves. There are only the mutual energy and mutual energy flow are left. There is no any energy is sent to the empty space and has been lost.

The above mutual energy theorem is suitable to the signal with very short time wave, for example the photon situation. A emitter sent a photon and an absorber receives a photon only with a very short time. Hence, we call this new theorem is a strong mutual energy theorem that has big difference compare with the original time-domain reciprocity theorem of Welch and the mutual energy theorem of author introduced in 1987.

Even in the antenna situation, the original mutual energy theorem of the author in 1987[15, 34, 33] tell us the mutual energy send from the transmitting antenna to the receiving antenna can be described by the mutual energy theorem. However there is still the possibility the antenna, can receive part of energy from the self-energy which is corresponding to the energy flow described by Poynting theorem which is

$$-\oint\!\!\!\oint (\boldsymbol{E}_1 \times \boldsymbol{H}_1) \cdot \hat{n} dA$$
$$= \iiint_V \boldsymbol{E}_1 \cdot \boldsymbol{J}_1 dV + \iiint_V (\partial \boldsymbol{B}_1 \cdot \boldsymbol{H}_1 + \boldsymbol{E}_1 \cdot \partial \boldsymbol{D}_1) dV \tag{134}$$

The new mutual energy theorem in this article or the stronger mutual energy theorem tell us that the self-energy flow corresponding to the self-energy flow of the transmitting antenna, $\oint\!\!\!\oint (\boldsymbol{E}_1 \times \boldsymbol{H}_1) \cdot \hat{n} dA$ Cannot be received by the receiving antenna of the current of the receiving antenna $\boldsymbol{J}_2$. Hence the new mutual energy theorem is much stronger than the original mutual energy theorem.

8.2 The mutual energy in Frequency domain

In Fourier domain the mutual energy theorem can be written as, this is looks the mutual energy theorem obtained by this author 30 years ago [15, 34, 33].

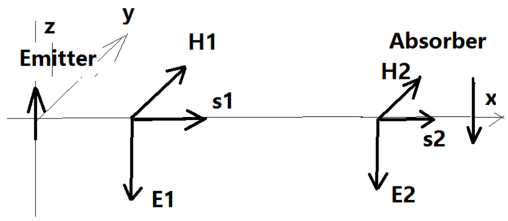

Figure 2: photon model, in this model the field $\zeta_1 = [\boldsymbol{E}_1, \boldsymbol{H}_1, \boldsymbol{J}_1]$,$\zeta_2 = [\boldsymbol{E}_2, \boldsymbol{H}_2, \boldsymbol{J}_2]$ all satisfy SCMEQ.

However the mutual energy theorem derived that time is also for transmitting antenna and receiving antenna. And the mutual energy formula tell us the receiving antenna received power is equal to a part of energy sent from the transmitting antenna to the receiving antenna. In antenna situation most power is sent to the whole space, there is only very small part energy from the total power will be received by the receiving antenna. But in this section the mutual energy principle is speak to photon situation. In this situation all energy sent out from the emitter is received by the absorber, if in the Fourier domain, we have,

$$-\iiint\limits_V \boldsymbol{E}_2^*(\omega)\cdot\boldsymbol{J}_1(\omega)dV = \iiint\limits_V \boldsymbol{E}_1(\omega)\cdot\boldsymbol{J}_2^*(\omega)dV \tag{135}$$

In the above formula the left site is the total power sent out from the emitter. The right site is the power received by the absorber. The new theorem can be referred as strong mutual energy theorem compare the author original mutual energy theorem in 1987.

Make a Fourier transform to the above formula we obtains,

$$-\int\limits_{-\infty}^{\infty}\iiint\limits_V \boldsymbol{E}_2(t+\tau)\cdot\boldsymbol{J}_1(t)dVdt = \int\limits_{-\infty}^{\infty}\iiint\limits_V \boldsymbol{E}_1(t)\cdot\boldsymbol{J}_2(t+\tau)dVdt \tag{136}$$

This formula same as the time-correlation reciprocity theorem of Adrianus T. de Hoop, [8].

If take $\tau = 0$, we obtained the mutual energy theorem Eq.(133) from 136.

8.3 Photon and mutual energy flow

Figure 2 shows the photon model of this kind solution. The emitter and absorber can be think as small antenna inside a atom. They also has their currents $\boldsymbol{J}_1$ and $\boldsymbol{J}_2$.

Assume we have put a metal plate between the emitter and the absorber. We make a big hole to allow the light to go through. The light goes from the emitter to the absorber. The mutual energy flow (will be defined in Eq.(138)) is

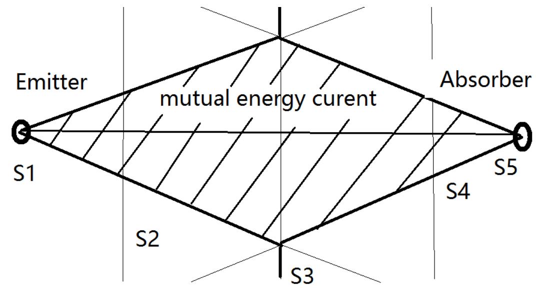

Figure 3: The mutual energy flow only exists at the overlap place of the two solutions of the SCMEQ. The field of the emitter is retarded wave. The field of the absorber is advanced wave.

exist only on the overlap of the two fields $\zeta_1 = [\boldsymbol{E}_1, \boldsymbol{H}_1]$ and $\zeta_1 = [\boldsymbol{E}_2, \boldsymbol{H}_2]$, see Figure 3 (it is possible there is still a little bit mutual energy flow outside the overlap region, but it become very weak). This overlap region create a perfect wave guide for the light wave. Inside this wave guide the normal TE (Transverse electric) and TM (Transverse magnetic) wave can be supported and they are perpendicular to each other and hence the polarization include linear and circle polarization of the waves all can be supported.

The disadvantage of this photon model is that it can only send the wave with linear polarization. If we need the photon as circular polarized field, we have to make the current $\boldsymbol{J}_1$ and $\boldsymbol{J}_2$ have two components for example along axis y and axis z, or to make the currents rotating along x axis. This is perhaps possible, because the electron is at spin, their current is also possible to have spin. In this way the radiate wave becomes circular polarization.

We can take the volume V only includes the emitter or only includes only the absorber, this way we can prove that the flux of the mutual energy flow go through each surface S_1, S_2, S_3, S_4 and S_5 are all equal, see [26, 24], that is,

$$-\int_{t=-\infty}^{\infty}\iiint_{V_1}(\boldsymbol{E}_2\cdot\boldsymbol{J}_1)$$
$$=Q_1=Q_2=Q_3=Q_4=Q_5$$
$$\int_{t=-\infty}^{\infty}\iiint_{V_2}(\boldsymbol{E}_1\cdot\boldsymbol{J}_2)dV \tag{137}$$

where Q_i is the flux of the mutual energy flow integral with time,

$$Q_i=\int_{t=-\infty}^{\infty}\oiint_{S_i}\cdot(\boldsymbol{E}_1\times\boldsymbol{H}_2+\boldsymbol{E}_2\times\boldsymbol{H}_1)\cdot\hat{n}d\Gamma dt \qquad i=1,2,3,4,5 \tag{138}$$

where $\hat{n}$ is normal vector of the surface S_i, the direction the normal vector is from the emitter to the absorber. This formula clear tells us the photon's energy flow is just the mutual energy flow. The mutual energy flow integral with time is equal at the 5 different surfaces or any other surfaces. We know that the surface S_1 and S_5 are very near to the emitter or absorber. This surface becomes so small, hence the wave beam is concentrated to a very small point. It looks very like a particle. In the middle, the wave beam is very thick. We can put other kind plate for example the metal plate with two slits. In this double-slit case the mutual energy flow (it is also some kind wave) will produce interference patterns. This can explain the wave-particle duality character of the photon. In the double-slit situation the above formula Eq.(137) can still be established. The above formula can be referred as the mutual energy flow theorem.

The left of the formula Eq.(137) can be seen as the energy sucked by the advanced wave $\xi_2 = [\boldsymbol{E}_2, \boldsymbol{H}_2]$ from the current of emitter $\boldsymbol{J}_1$. The right of the formula Eq.(137) can be seen as the current of the absorber $\boldsymbol{J}_2$ received the energy from the retarded wave $\xi_1 = [\boldsymbol{E}_1, \boldsymbol{H}_1]$. Integral of this energy with time is equal to each other and all equal to the integral of mutual energy flow in each surface S_i. The mutual energy flow is produced with retarded wave and advanced wave together. The two waves must be synchronized. The retarded wave can be referred as emitting wave of the emitter. The advanced wave can be referred as receiving wave of the absorber.

8.4 Proof of the mutual energy flow theorem

The proof is not difficult, however from the author introduce the mutual energy theorem to mutual energy flow theorem 30 years has passed. The author has call the theorem as a energy theorem, but actually in that time did not prove the theorem is a energy theorem. Best way to prove it is a energy theorem is prove the mutual energy theorem form Poynting theorem. All people can accept the Poynting theorem is energy theorem, if mutual energy theorem can be proved form Poynting theorem, it is clear that the mutual energy theorem is a energy theorem. The author cannot prove mutual energy theorem form Poynting theorem in 1987. The author has chosen a wrong Poynting theorem. Actually the Poynting theorem has two formulas one is in time-domain, one is in Fourier frequency domain. The two theorems are two different theorems instead of one theorem connected by Fourier transform. Hence the author stop there. It is only recently when the author proved that the mutual energy theorem can be seen as a sub-theorem of the Poynting theorem[19], the author begin to think the new question, that is if the energy can be transferred there should be some energy flow in the space. Hence the author begin to find the mutual energy flow theorem[24, 17]. The proof is describe as following, the mutual energy theorem with surface integral can be written as,

$$-\int_{t=-\infty}^{\infty} \oiint_{\Gamma} \cdot(\boldsymbol{E}_1 \times \boldsymbol{H}_2 + \boldsymbol{E}_2 \times \boldsymbol{H}_1) \cdot \hat{n} d\Gamma dt$$

$$= \int_{t=-\infty}^{\infty} \iiint_V (\boldsymbol{E}_2 \cdot \boldsymbol{J}_1 + \boldsymbol{E}_1 \cdot \boldsymbol{J}_2) dV dt$$

Here the surface Γ is any surface for example a very big sphere. V is the volume inside the sphere surface. Since the surface can be take as any surface, we can choose it as a surface of V_1. $V_1$is the place of the emitter $\boldsymbol{J}_1$. The above equation can be written as,

$$- \int_{t=-\infty}^{\infty} \oiint_{\Gamma_1} \cdot (\boldsymbol{E}_1 \times \boldsymbol{H}_2 + \boldsymbol{E}_2 \times \boldsymbol{H}_1) \cdot \hat{n} d\Gamma dt$$

$$= \int_{t=-\infty}^{\infty} \iiint_{V_1} \boldsymbol{E}_2 \cdot \boldsymbol{J}_1 dV dt$$

or

$$- \int_{t=-\infty}^{\infty} \iiint_{V_1} \boldsymbol{E}_2 \cdot \boldsymbol{J}_1 dV dt = \int_{t=-\infty}^{\infty} \oiint_{\Gamma_1} \cdot (\boldsymbol{E}_1 \times \boldsymbol{H}_2 + \boldsymbol{E}_2 \times \boldsymbol{H}_1) \cdot \hat{n} d\Gamma dt$$

In the same way, we can have,

$$\int_{t=-\infty}^{\infty} \oiint_{\Gamma_2} \cdot (\boldsymbol{E}_1 \times \boldsymbol{H}_2 + \boldsymbol{E}_2 \times \boldsymbol{H}_1) \cdot \hat{n} d\Gamma dt$$

$$= \int_{t=-\infty}^{\infty} \iiint_{V_2} \boldsymbol{E}_1 \cdot \boldsymbol{J}_2 dV dt$$

In this formula the direction of the surface $\hat{n}$ is directed from inside of V_2 to the outside of V_2. Hence it is directed from V_2 to V_1. We changed the direction of $\hat{n}$ to the opposite direction which is on is from V_1 to V_2. The above formula can be rewritten as,

$$\int_{t=-\infty}^{\infty} \oiint_{\Gamma_2} \cdot (\boldsymbol{E}_1 \times \boldsymbol{H}_2 + \boldsymbol{E}_2 \times \boldsymbol{H}_1) \cdot \hat{n} d\Gamma dt = \int_{t=-\infty}^{\infty} \iiint_{V_2} \boldsymbol{E}_1 \cdot \boldsymbol{J}_2 dV dt$$

substitute the above two formula to Eq.(133), we obtained that,

$$- \int_{t=-\infty}^{\infty} \iiint_{V_1} \boldsymbol{E}_2 \cdot \boldsymbol{J}_1 dV dt = \int_{t=-\infty}^{\infty} \oiint_{\Gamma_1} \cdot (\boldsymbol{E}_1 \times \boldsymbol{H}_2 + \boldsymbol{E}_2 \times \boldsymbol{H}_1) \cdot \hat{n} d\Gamma dt$$

$$= \int_{t=-\infty}^{\infty} \oiint_{\Gamma_2} \cdot(\boldsymbol{E}_1 \times \boldsymbol{H}_2 + \boldsymbol{E}_2 \times \boldsymbol{H}_1) \cdot \hat{n} d\Gamma dt = \int_{t=-\infty}^{\infty} \iiint_{V_2} \boldsymbol{E}_1 \cdot \boldsymbol{J}_2 dV dt$$

or

$$-\int_{t=-\infty}^{\infty} \iiint_{V_1} \boldsymbol{E}_2 \cdot \boldsymbol{J}_1 dV dt$$
$$= Q_1 = Q_2$$
$$= \int_{t=-\infty}^{\infty} \iiint_{V_2} \boldsymbol{E}_1 \cdot \boldsymbol{J}_2 dV dt$$

Where,

$$Q_1 = \int_{t=-\infty}^{\infty} \oiint_{\Gamma_1} \cdot(\boldsymbol{E}_1 \times \boldsymbol{H}_2 + \boldsymbol{E}_2 \times \boldsymbol{H}_1) \cdot \hat{n} d\Gamma dt$$

$$Q_2 = \int_{t=-\infty}^{\infty} \oiint_{\Gamma_2} \cdot(\boldsymbol{E}_1 \times \boldsymbol{H}_2 + \boldsymbol{E}_2 \times \boldsymbol{H}_1) \cdot \hat{n} d\Gamma dt$$

Actually that the surface Q_1 and Q_2 can be chosen as any complete surface between the emitter $\boldsymbol{J}_1$ and the absorber $\boldsymbol{J}_2$. The proof is finiseshed.

8.5 The inner product of the electromagnetic fields

The author has defined inner product for electromagnetic field[15] by

$$(\xi_1, \xi_2) \equiv \oiint_{\Gamma_i} \cdot(\boldsymbol{E}_1(\omega) \times \boldsymbol{H}_2^*(\omega) + \boldsymbol{E}_2^*(\omega) \times \boldsymbol{H}_1(\omega)) \cdot \hat{n} d\Gamma \qquad i = 1, 2, 3, 4, 5 \tag{139}$$

$$(\xi_1, \xi_2) \equiv \int_{t=-\infty}^{\infty} \oiint_{\Gamma} \cdot(\boldsymbol{E}_1(t) \times \boldsymbol{H}_2(t) + \boldsymbol{E}_2(t) \times \boldsymbol{H}_1(t)) \cdot \hat{n} d\Gamma dt \tag{140}$$

If Γ_i is the big sphere, it can be prove that, if the sources of ξ_1 and ξ_2 are inside the surface Γ_i. Assume ξ_1 and ξ_2 are all retarded fields There are,

(I) Conjugate symmetry:

$$(\xi_1, \xi_2) = (\xi_2, \xi_2)^* \tag{141}$$

(II) linearity:

$$(a\xi_1 + b\xi_2, \xi_3) = a(\xi_1, \xi_3) + b(\xi_2, \xi_3) \tag{142}$$

(III) Positive-definiteness:

$$(\xi_i,\xi_i)\geq 0 \tag{143}$$

$$(\xi_i,\xi_i)=0 \qquad \Leftrightarrow \ \xi_i=0 \tag{144}$$

(ξ_1,ξ_2) are very good inner space of the electric magnetic fields. If (ξ_1,ξ_2) are all advanced fields the above conclusion can also be established.

It is important that if the (ξ_1,ξ_2) one is retarded wave and another is advanced wave, the inner product can be defined at any surface between the two charges, one is the emitter and the other is absorber. In this situation, since the two field cannot be equal, because one is retarded field and another is advanced wave. Hence the condition (III) do not need to satisfy. In the situation the two waves are same, this inner product can be applied to do the wave expansion, for example, sphere the wave expansion[15] or the plane wave expansion[33]. These two situations are applied to the mathematical applications, the surface Γ are taken as any surface outside of the sources $\boldsymbol{J}_1,\boldsymbol{J}_2$. In case the two wave one is a retarded wave and the other is an advanced wave, the surface Γ is taken at any place between $\boldsymbol{J}_1$ and $\boldsymbol{J}_2$. This inner product is just the mutual energy flow. Hence, there is

$$Q_i=(\xi_1,\xi_2)=\int\limits_{t=-\infty}^{\infty}\ \oiint\limits_{\Gamma_i}\cdot(\boldsymbol{E}_1\times\boldsymbol{H}_2+\boldsymbol{E}_2\times\boldsymbol{H}_1)\cdot\hat{n}d\Gamma dt \qquad i=1,2,3,4,5 \tag{145}$$

We also written

$$(\tau_1,\xi_2)_{V_1}=\int\limits_{t=-\infty}^{\infty}\ \iiint\limits_{V_1}(\boldsymbol{E}_2\cdot\boldsymbol{J}_1+H_2\cdot\boldsymbol{K}_1)dV \tag{146}$$

$$(\tau_2,\xi_1)_{V_2}=\int\limits_{t=-\infty}^{\infty}\ \iiint\limits_{V_2}(\boldsymbol{E}_1\cdot\boldsymbol{J}_2+H_1\cdot\boldsymbol{K}_2)dV \tag{147}$$

where $\boldsymbol{K}_1$ and $\boldsymbol{K}_2$ are magnetic current intensity, $\tau_1=[\boldsymbol{J}_1,\boldsymbol{K}_1]$, $\tau_2=[\boldsymbol{J}_2,\boldsymbol{K}_2]$. It is clear that the above formulas also satisfy the inner product 3 conditions. Hence, we can written them as inner products. Here we have $\boldsymbol{K}_1=0$, $\boldsymbol{K}_2=0$. Hence, the mutual energy flow theorem can be rewritten as,

$$-(\tau_1,\xi_2)_{V_1}=(\xi_1,\xi_2)=(\tau_2,\xi_1)_{V_2} \tag{148}$$

8.6 Int is possible that to have the mutual energy flow for the time-reversal waves

Originally the author thought the time-reversal fields do not produce the mutual energy flow. But this is not consist with a complete theory. Why the retarded wave and the advanced wave can interfere with each other and produce the mutual energy flow, but the corresponding time-reversal fields cannot produce the mutual energy flow? The problem is if we allowed the time-reversal fields also produce the mutual energy flow, this time-reversal mutual energy flow can completely cancel the original mutual energy flow. However there is also a situation we need the mutual energy flow also to return to their sources. Hence the author assume the mutual energy flow theorem is also established as flowing,

$$-(\tau_1', \xi_2')_{V_1} = (\xi_1', \xi_2') = (\tau_2', \xi_1')_{V_2} \tag{149}$$

where

$$(\tau_1', \xi_2')_{V_1} = \int_{t=-\infty}^{\infty} \iiint_{V_1} (\boldsymbol{E}_2' \cdot \boldsymbol{J'}_1 + \boldsymbol{H}_2' \cdot \boldsymbol{K'}_1) dV \tag{150}$$

$$(\tau_2', \xi_1')_{V_2} = \int_{t=-\infty}^{\infty} \iiint_{V_2} (\boldsymbol{E}_1' \cdot \boldsymbol{J'}_2 + \boldsymbol{H}_1' \cdot \boldsymbol{K'}_2) dV \tag{151}$$

The time-reversal mutual energy flow is defined as following,

$$Q_i' = (\xi_1', \xi_2')$$

$$= -\int_{t=-\infty}^{\infty} \oiint_{\Gamma_i} \cdot (\boldsymbol{E'}_1 \times \boldsymbol{H'}_2 + \boldsymbol{E'}_2 \times \boldsymbol{H'}_1) \cdot \hat{n} d\Gamma dt \qquad i = 1, 2, 3, 4, 5 \tag{152}$$

Please notice in the above formula there is negative symbol in the front of the formula, this negative symbol is used to let the above formula have a positive value.

Hence, now the author believe that it is possible that the two time-reversal waves, one is corresponding to the retarded wave, one is corresponding to the advanced wave can interfere with each other and also produce their mutual energy flow. This is because they satisfy the same equations: the time-reversal Maxwell equations. Hence, they should be possible to interfere with each other, these two fields will produce another kind of mutual energy and mutual energy flow. This is very similar to the normal mutual energy flow. Here the normal mutual energy flow is referred as the mutual energy flow which are produced by the retarded wave and the advanced wave. The new kind of the mutual energy flow is referred as time-reversal mutual energy flow which is produced by two time-reversal wave corresponding to the retarded wave and the advanced wave.

In case there is the race, that is there is two advanced waves have matched with one retarded wave. Hence the two absorbers each obtains half energy package from the retarded wave. Since the half-retarded wave bring only half photon which is not enough to allow the electron in the absorber from lower energy level to spring to a higher energy level. In this case, the energy is returned to the original level. There is a time-reverse current $\boldsymbol{J}_2'$ cancel the

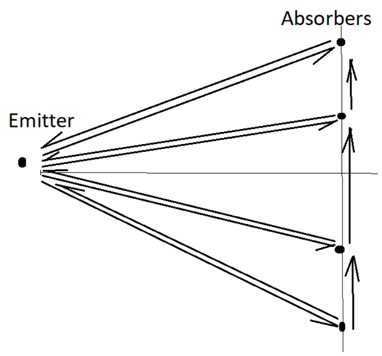

Figure 4: In case of race, an absorber only receive a half photon or a part of photon, in this case the energy is allowed to be returned through the time-reversal mutual energy flow. In this way, the energy on the detector screen can flow from one absorber to another. Once an absorber received an energy of whole photon, it will locked this energy and does not allow this energy to return. The energy is sent form the emitter to the absorber in this way.

received current J_2. Because of $\boldsymbol{J}'_2$, it has $(\xi'_1, \tau'_2) \neq 0$, and hence, $(\xi'_1, \xi'_2) \neq 0$, and hence, $(\xi'_2, \tau'_1) \neq 0$. This time-reversal mutual energy flow will balance out the normal mutual energy flow, which means following,

$$(\tau'_1, \xi'_2)_{V_1} + (\tau_1, \xi_2)_{V_1} = 0 \tag{153}$$

$$(\tau'_2, \xi'_1)_{V_2} + (\tau_2, \xi_1)_{V_2} = 0 \tag{154}$$

$$(\xi'_1, \xi'_2) + (\xi_1, \xi_2) = 0 \tag{155}$$

Hence, for the mutual energy, if an energy item increase, the corresponding time-reversal items will decrease, hence all items are balanced out or canceled.

Hence, the time-reversal waves can offer a function that the energy can be sent and also returned even with many times. The energy can be oscillated between the emitter and many absorbers.

This way the energy have the ability flow from one absorber to other absorber. If one absorber obtains a whole photon energy package, this energy will be locked by this absorber and do not allow it to leave. This energy package will not returned by the absorber. Otherwise the energy can leave this absorber, return to its emitter and then flow to other absorber.

8.7 It is possible that the time-reversal mutual energy flow is 0

the time-reversal self-energy flow can be nonzero, but it is possible that the time-reversal mutual energy flow is 0.

We know that the mutual energy can be written as inner product (ξ_1, ξ_2), here $\xi_1 = [\boldsymbol{E}_1, \boldsymbol{H}_1]$ is the retarded wave, $\xi_2 = [\boldsymbol{E}_2, \boldsymbol{H}_2]$ is the advanced wave. This is because the inter products

$$-(\tau_1, \xi_2)_{V_1} = (\xi_1, \xi_2) = (\tau_2, \xi_1)_{V_2} = 0 \tag{156}$$

The inner product is 0 means the two field ξ_1 and ξ_2 are orthogonal. We only need to make one of the inner product 0 is OK. For example,

$$(\tau_1, \xi_2)_{V_1} = \int_{t=-\infty}^{\infty} \iiint_{V_1} (\boldsymbol{E}_2 \cdot \boldsymbol{J}_1) = 0 \tag{157}$$

This means that $\boldsymbol{E}_2 \perp \boldsymbol{J}_1$, here "$\perp$" are some kind of perpendicular.

It the same to the time-reversal mutual energy flow which is the mutual energy flow of the two time-reversal waves. That means we can have,

$$-(\tau_1', \xi_2')_{V_1} = (\xi_1', \xi_2') = (\tau_2', \xi_1')_{V_2} = 0 \tag{158}$$

This formula tell us that the time-reversal mutual energy flow can be nonzero or zero according to the different situation. In case the absorber receive a whole photon energy package, this energy will be detained by the absorber and hence need,

$$(\tau_2', \xi_1')_{V_2} = 0 \tag{159}$$

This will make the system with $(\xi_1', \xi_2') = 0$. This will not allow the energy to return to the emitter. In case the energy obtained by the absorber is not enough as a whole photon energy package, the electron charge of the absorber cannot spring from a lower energy level to a higher energy level. This charge spring to a half energy level and it will returns to it's original energy level. Hence, this energy is allowed to return and the time-reversal mutual energy flow $(\xi_1', \xi_2') \neq 0$.

The major criticism to the transactional interpretation of the quantum mechanics of John Crammer is that if the offering wave (which is the retarded wave) has been received by two or more absorbers, why only one absorber win the photon energy? And why only this absorber sends back the confirm wave? We know in computer science, a transactional process includes a money return function. For example, if two senders try to send money to one receiver in exactly same time, the race condition happened, the transactional processes are not successful, then the money in these two processes must be returned to their senders. Transactional interpretation of John Cramer is only qualitative theory which cannot offer very details includes about this money return function. Our mutual energy flow theory is a quantitative theory, which have to offer this function. So the energy will same as the money can be returned through time-reversal mutual energy flow.

9 The collapse of the wave function

The transferring of the photon energy starts from a point and ends at a point. But the wave according to the Maxwell equations spreads from the source point to the entire empty space. In order to explain this phenomenon with the retarded wave, the concept of wave function collapse is created. This concept is very rough, if there are many partition boards with a small holes between the emitter charge and the absorber charge. The light is clear can go through all these small holes from emitter to the absorber. But according to the concept of the wave function collapse the wave must collapse N times if there are N partition boards with holes. Collapse in one hole is strange enough, if the wave collapse N times, that is unbelievable! In another article we have proved that the photon energy is actually transferred by the "mutual energy flow" which is point to point instead spreads to the entire space. Since energy can be transferred by the mutual energy flow, the concept of the wave function collapse is not necessary. In order to build the mutual energy flow it is required to build the self-energy flow also. The self-energy flow is spread to the entire empty space. What will do for the self-energy flow? it is possible the self-flow also collapse to the absorber. However if self-energy flow collapse, we have also meet the same problem as the whole wave collapse. That means if there are N partition sheets with N holes, the self-energy flow has to collapse N times. In the article about mutual energy principle we have propose another possibility in which the self-energy flow instead collapse, we believe it is time-reversal returned. It is returned with a time reversal process, hence the self-energy dose not contributed to the energy transfer of the photon. The time-reversal process can be seen as also a collapse process also, however it is collapse to the source of the wave instead of the target of the wave. In this article we will discuss the self-energy flow and the time reversal process in details.

9.1 If there are more partition boards between the emitter and the absorber

The time-reversal field is very like the wave function collapse, the wave function collapse is that the wave collapse to its target. That means the energy is transferred from a point and ended at another point. The time-reversal field is a collapse process that it collapses to its source instead to the target, i.e. the wave collapse to its starting point.

When a wave collapse to its target, for example a retarded wave send out from the emitter collapses to its absorber, an advanced wave sent from absorber collapses to its emitter. For this kind collapse process none can offer a mathematical equation to describe it. It is a guess even cannot be mathematically formulated.

A deadliness problem for the concept of wave function collapse is that if there are a few partition boards with a hole on it, between the emitter and the absorber, it is clear that light can go through these holes from the emitter to the absorber. However according to the concept of wave function collapse, the

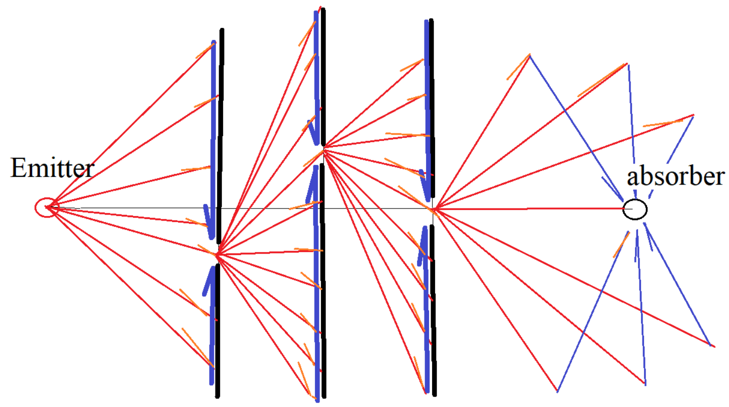

Figure 5: There is a emitter and absorber. Between the emitter and the absorber there are a few partition boards. On the partition boards there is a hole for each board to allow light to go through. This figure shows the retarded wave collapse on each hole. Red line is the retarded wave. Blue line is the process of the collapsed wave. The retarded wave collapse on holes of each partition board. In the end the wave collapses at the absorber. This is unbelievable.

wave has to collapse at each hole so that the light can go through these holes on the partition boards and to reach the target which is the absorber. Even we can accept that the wave collapse to its target, i.e. the absorber, we are still difficult to accept that the wave collapse at each holes on the partition boards. See Figure 5.

In other hand, the mutual energy flow can go through this holes without problem. The self energy flow can easily time-reversal return to its source. See Figure 6.

We have mentioned there is a power over estimation for a system with N charges. This over estimation suggest us that there should be no any contribution to the energy transfer by self-energy flow. If self-energy flow is collapse to its target, then it is clear the self-energy flow will play a role for the transfer of the energy. However the mutual energy theorem guarantees that the mutual energy flow just transfer a package of energy for one photon. This also suggest the self-energy should not collapse to its target to contribute additional energy. It should collapse to its source. This kind of wave function collapse is actually not a collapse process, it is referred as time-reversal process. Time-reversal process satisfy time-reversal Maxwell equations instead of the Maxwell equations.

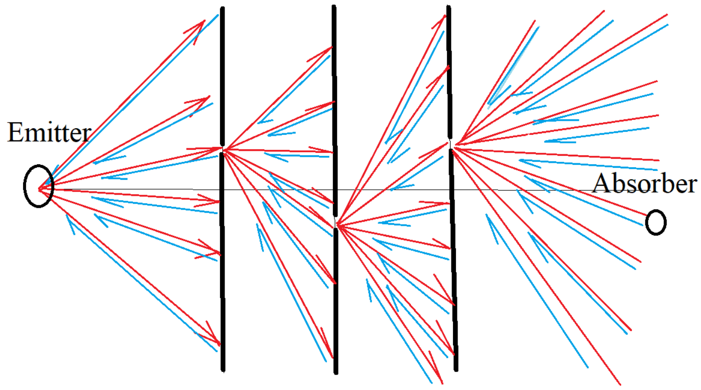

Figure 6: There is a emitter and absorber. Between the emitter and the absorber there are a few partition boards. On the partition board there is a hole to allow light to go through. The self energy flow can go through this system and time-reversal return to its source. This figure shows that the retarded wave time-reversal return to the emitter. Red line is the retarded wave. Blue line is the time-reversal wave which can time-reversal return to the emitter.

9.2 It looks like a collapse process when combining the mutual energy flow and self-energy flow

Assume the emitter sends the retarded wave to the absorber. The absorber sends the advanced wave to the emitter. This two waves have two self-energy flows. They also produce one mutual energy flow. The mutual energy flow is responsible to transfer the energy from emitter to the absorber. The self-energy flows are returned through the time-reversal processes. The above described processes together function exactly like a wave function collapse process. The energy now is sent from emitter to the absorber. It looks like the energy is collapsed to the absorber. There is no any energy send to the whole space. The energy is sent from a point (the emitter) to another point (absorber).

Hence the wave function collapse can be implemented by the two processes: one is the energy is transferred through the mutual energy flow, another one is all self-energy flows are returned by the time-reversal processes.

10 Mutual energy flow interpretation for quantum mechanics

10.1 Race situation

There are situation in which perhaps two advanced waves match one retarded wave. Or two retarded waves match one advanced wave. This is a race situation. Race situation happens also in the computer software technology. There are situations where two threads try to write something to a same memory element. One of solution to this race situation is that the two threads work are all revoked. The author believe the race process for the waves are the same. If the race case happens, the two mutual energy flows are time-reversal returned through two time-reversal mutual energy flows. In this time the time-reversal process will also bring the mutual energy flow back. If absorber receive a whole photon energy package, this photon energy will be locked by the absorber and do not allow it to be time-reversal returned. The electron charge in the absorber will spring from a lower energy level to a higher energy level. If it received only a half photon energy package, this half photon has to be time-reversal returned.

10.2 The photon as a whole energy package, it is possible doesn't time-reversal return

If a whole photon has been sent with the mutual energy flow from the emitter to the absorber, the author believe this energy has been captured by the absorber and does not allow this energy to be time-reversal returned.

We have said that the self-energy flow for the retarded wave and advanced wave after the mutual energy flow is sent from the emitter to the absorber, they time-reversal returned. If this time-reversal waves are interfered with each other, it will produced also their mutual energy, which will make the normal mutual energy flow time-reversal return to its emitter. This situation is not what we wanted, hence we assume that if the photon has be sent from emitter to the absorber, then it is possible that the two time-reversal waves corresponding to retarded wave and the advanced wave do not interfere with each other and hence do not produce any mutual energy flow for the time-reversal waves.

In the half-photon race situation we allow the time-reversal waves interfere each other to produce the time-reversal mutual energy flow which brings the half photon energy package back to its source. In the situation there is no race, the two time-reversal waves should not interfere and should not bring the whole photon energy package back. We know the mutual energy flow theorem, the corresponding mutual energy theorem for the time-reversal waves are flowing,

$$-\int_{t=-\infty}^{\infty} \iiint_{V_1} (\boldsymbol{E}'_2 \cdot \boldsymbol{J'}_1)$$

$$= (\xi'_1, \xi'_2)$$

$$\int_{t=-\infty}^{\infty} \iiint_{V_2} (\boldsymbol{E}'_1 \cdot \boldsymbol{J'}_2) dV \tag{160}$$

The mutual energy flow of the time-reversal wave can vanish through change the time-reversal returned current $\boldsymbol{J'}_1 \neq 0$ and $\boldsymbol{J'}_2 \neq 0$ hence the following formula is established.

$$\boldsymbol{J}'_2 = 0 \tag{161}$$

$$\int_{t=-\infty}^{\infty} \iiint_{V_2} (\boldsymbol{E}'_1 \cdot \boldsymbol{J}'_2) dV = 0 \tag{162}$$

$\boldsymbol{J}'_2 = 0$ means the electron charge in the absorber spring to the higher energy level, but does not spring back to the original energy level. If it spring back then $\boldsymbol{J'}_2 \neq 0$. Hence the mutual energy flow for the time-reversal wave is possible do not carry any energy. In case the whole package of photon energy is sent from the emitter to the absorber, this energy has been captured by the absorber, the absorber will not allow the energy time-reversal to return to the emitter.

10.3 The mutual energy flow interpretation

The theory about the mutual energy and self-energy principle can be applied to build a interpretation for quantum mechanics. It is referred as the mutual energy flow interpretation.

The mutual energy flow interpretation can be seen as a upgraded version of the transactional interpretation of John Cramer. Because both interpretation need advanced waves and retarded waves. A major attack to the transactional interpretation is that it cannot offer a explanation about how to solve the above race situation. The transactional interpretation cannot tell us why only one confirming wave only respond the offering wave. The mutual energy flow interpretation did not has this problem. In the race situation, for example the two absorbers all obtained half photon energy, this energy not enough to allow the electron in the absorber to spring to a higher level. The half photon mutual energy received by the absorber will time-reversal return to its source. In this case the current $\boldsymbol{J}'_2 \neq 0$, which will allow to produced a time-reversal mutual energy flow, which will balance out the original mutual energy flow.

Figure 7 shows the situation if race happens. Assume in the beginning no absorber obtains a enough energy to allow the electron to spring to a higher level. The energy will return to the emitter. This return process is through the time-reversal mutual energy flow. The energy will be resent from the emitter to the absorbers again. We assume that the two closed absorber the one have received more energy will win, hence the one with less energy will lose their energy. The winner will obtain all the energy includes it's energy and the neighbor's energy. This way the energy eventually flows from many absorbers to only one absorber. This absorber is the final winner, the electron charge inside this absorber will

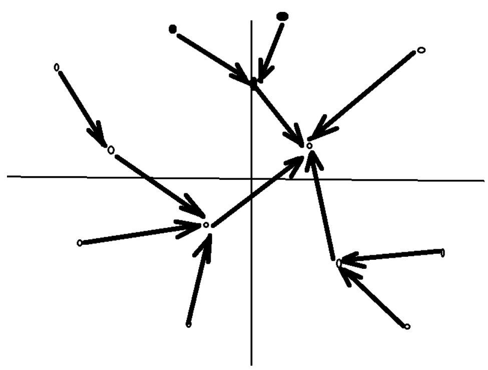

Figure 7: This figure shows it is possible in the beginning that the energy of the retarded wave is sent to a few absorbers. However since the absorber received energy is not enough to bring the electron inside the absorber to spring to a higher level, the energy is time-reversal returned to the emitter, from emitter it is resent out and can be received by another absorber. This looks like the energy can be flow on the detector screen. We assume the closed two absorber the one with more energy will win. The one with less energy will lose their energy. The energy will flow from the loser to the winner. Eventually one absorber win a whole package of a photon energy. The electron inside this absorber will spring to the high energy level and locked the energy do not allow it return. This process looks exactly like a wave function collapse process.

spring from a lower energy level to a higher energy level and locked the energy to the higher level do not allow it to return. There is $\boldsymbol{J}_2' = 0$. This process will look very like a wave function collapse process. Hence, the author's mutual energy flow theory with 4 waves and 6 energy flows offers a function similar to the wave function collapse. But here, actually, there is no any wave function collapse. All wave are either satisfy the Maxwell equations or time-reversal Maxwell equations, they together worked with the mutual energy principle and self-energy principle.

10.4 The interpretation about the probability in quantum mechanics

We know that in quantum mechanics the probability of the photon or other particle appearing in the target screen is equal to the square of the absolute value of the amplitude of wave function, i.e.,

$$P(\boldsymbol{x}) = |\psi(\boldsymbol{x})|^2 \tag{163}$$

where $P(\boldsymbol{x})$ is the probability intensity function. $\psi(\boldsymbol{x})$ is the wave function. For photon, $\psi(\boldsymbol{x})$ can be seen as the vector potential and scale potential $(\boldsymbol{A}(x), \phi(x))$ or it can be seen as $\xi = (\boldsymbol{E}(\boldsymbol{x}), \boldsymbol{H}(\boldsymbol{x}))$.

According to the mutual energy theorem Eq.(160), the absorber current $\boldsymbol{J}_2$ can obtained the energy is,

$$Q_2 = \int_{t=-\infty}^{\infty} \iiint_{V_2} (\boldsymbol{E}_1 \cdot \boldsymbol{J}_2) dV \tag{164}$$

Which is in direct proportion to $\boldsymbol{E}_1(\boldsymbol{x}_2)$. The author assume the current $\boldsymbol{J}_2(\boldsymbol{x}_2)$ will be also direct proportion to $\boldsymbol{E}_1(\boldsymbol{x}_2)$. Hence, we have,

$$\boldsymbol{J}_2(\boldsymbol{x}_2) = \sigma \boldsymbol{E}_1(\boldsymbol{x}_2) \tag{165}$$

where σ is a electric conductivity constant. Hence, the mutual energy flow is

$$Q_2 = \int_{t=-\infty}^{\infty} \iiint_{V_2} (\boldsymbol{E}_1(\boldsymbol{x}_2, t) \cdot \sigma \boldsymbol{E}_1(\boldsymbol{x}_2, t)) dV dt \tag{166}$$

If we need to find the corresponding formula in Fourier domain, we have to extended the above formula to a form of correlation,

$$Q_2(\tau) = \int_{t=-\infty}^{\infty} \iiint_{V_2} (\boldsymbol{E}_1(\boldsymbol{x}_2, t+\tau) \cdot \sigma \boldsymbol{E}_1(\boldsymbol{x}_2, t)) dV dt \tag{167}$$

In the correlation formula, if $\tau = 0$, we can obtained the $Q_2(\boldsymbol{x}_2)$. Make a Fourier transform to the above formula we have,

$$Q_2(\omega) = \sigma \iiint\limits_{V_2} (\boldsymbol{E}_1(\boldsymbol{x}_2,\omega)\cdot\boldsymbol{E}_1^*(\boldsymbol{x}_2,\omega))dV$$

$$= \sigma \iiint\limits_{V_2} |\boldsymbol{E}_1(\boldsymbol{x}_2,\omega)|^2 dV \tag{168}$$

From this we can define the photon's mutual energy intensity as the integrand of the above equation, hence the energy intensity is,

$$q(\boldsymbol{x}_2,\omega) = \sigma|\boldsymbol{E}_1(\boldsymbol{x}_2,\omega)|^2 \tag{169}$$

This is the reason that the probability become,

$$P(x_2) \propto |\boldsymbol{E}_1(\boldsymbol{x}_2,\omega)|^2 \tag{170}$$

where$\propto$ means "direct proportion to".

But the photon's appear proportion to the energy intensity function still need to discussion more. The energy distribution function only tells that region how fast the energy can be absorbed. If the energy intensity is large, the absorber in that point can get energy quickly. But if we adjust the source energy to very low level hence only one photon appear in a time. If there is only one pair of the emitter and the absorber are synchronized, the probability is only decided by the time of random movement of all absorber. That means if the absorber is just synchronized with the emitter, it will obtained the photon. In this case the appearance of the probability of the photon will not related to the received energy intensity $|\boldsymbol{E}_1(\boldsymbol{x}_2,\omega)|^2$. The probability will near a constant to all directions. This is a uniform distribution.

In order the appearance probability of the photon is direct proportion to energy intensity function, that need the energy is received by a region instead of only one or two location. The energy received in the some region must flow to a point in that region. Hence if the energy intensity is higher, the region will quickly contribute a photon. Hence that region will have the high probability for the photon to appear. The last sub-section we have discussion the possibility that the energy can be flow from surrounding place to one point by a "collapse" process. This collapse process is not a really a collapse, the energy actually is returned to its source by time-reversal mutual energy flow. The energy is recent by the source, this energy is re-received by a nearby absorber. We assume some reason this energy have some tension which will force them to be concentrated. This is energy tension very similar to the oil drop, even the oil is spilled to a region, the oil drop is concentrated to one point because of the tension in it.

Hence the synchronization process is only offer the photo appear randomly. But the collapse function in the whole region can guarantee the photon appear to proportion to the energy density function.

This also closed the debate about what is the probability in the quantum mechanics. Some people claim the wave function is the real energy function, some claim it is a probability function. Now we are clear the wave function is a energy density function, but the point where a absorber will receive the energy is a random point with the appearance probability direct proportion to the energy density of the retarded wave. This energy density is the absorption energy density which is equal to the mutual energy flow energy density.

In the above we have only discussion the case where the probability density or energy density density is continual. In case of the absorption is not continual but discrete, we will assume that the energy flow only flow or collapse on the same energy level. This will guarantee if that energy level the density is higher, that energy level will obtains higher probability of the appearance of the photon.

11 The correct way for defining the electromagnetic field and the superposition principle

In the above we have said superposition principle has the problem, it should be replaced by the mutual energy principle. This section we should make clear what is wrong with superposition principle and how to correct it, these also involve the problem how to define the electric field and magnetic field.

Assume there is a electric charge q_1, it is at the position $\boldsymbol{x}_1$. In the position $\boldsymbol{x}_2$ there is a test charge q_2. In order to make superposition principle to work, first we should define what is the field. We know that the electric field is defined as the force divided the charge amount of the test charge q_2. The force on the test charge is

$$\boldsymbol{F}(\boldsymbol{x}_1, \boldsymbol{x}_2) = kq_1q_2\frac{\boldsymbol{r}}{r^3} \tag{171}$$

where k is a constant, $\boldsymbol{r} = \boldsymbol{x}_2 - \boldsymbol{x}_1$ $r = ||\boldsymbol{r}||$, we define the field as

$$\boldsymbol{E}(\boldsymbol{x}_1, \boldsymbol{x}_2) = \frac{\boldsymbol{F}(\boldsymbol{x}_1, \boldsymbol{x}_2)}{q_2} \tag{172}$$

Where $\boldsymbol{F}(\boldsymbol{x}_1, \boldsymbol{x}_2)$ is the force of the charge q_1 applied to the charge q_2. $\boldsymbol{E}(\boldsymbol{x}_1, \boldsymbol{x}_2)$ is the field of charge q_1 applied to the charge q_2. We said the field at the position $\boldsymbol{x}_2$ is

$$\boldsymbol{E}(\boldsymbol{x}_1, \boldsymbol{x}_2) = kq_1\frac{\boldsymbol{r}}{r^3} \tag{173}$$

Now, the question is this result correct? Of cause No! It is only correct if the the test charge is there. If the test charge q_2 is removed from the space, who knows that the field is still $\boldsymbol{E}(\boldsymbol{x}_1, \boldsymbol{x}_2) = \frac{\boldsymbol{F}(\boldsymbol{x}_1, \boldsymbol{x}_2)}{q_2}$? The electric field is not defied, if the q_2 is removed. According to the Maxwell field theory this field is a real field, it exist. According the theory of action-at-a-distance [28, 10, 30], the absorber theory of Wheeler and Feynman [1][2], the author's mutual energy principle, since a action and a reaction must take place at least with two charges, if the test charge is removed the action and reaction is also disappeared. Hence the field can not be correctly defined in this case.

Hence the field must defined on a charge. Assume there are currents $\boldsymbol{J}_1$ and $\boldsymbol{J}_2$. If we need to know the field at the place of $\boldsymbol{J}_2$. This field can be superposed, hence we have,

$$E(\boldsymbol{x}_2) = \iiint\limits_{V_1} G(\boldsymbol{x}_1, \boldsymbol{x}_2)\boldsymbol{J}_1(\boldsymbol{x}_1)dV \tag{174}$$

Here $E(\boldsymbol{x}_2)$ only defined on the region V_2, $\boldsymbol{x}_2 \notin V_1.V_2$ is the region for $\boldsymbol{J}_2 \neq 0$.

Here $G(\boldsymbol{x}_1, \boldsymbol{x}_2)$ is the green function. However, if we need to know the field inside the V_1 , for example $x \in V_1$

$$E(\boldsymbol{x}) = \lim_{r_\epsilon \to 0} \iiint\limits_{V_1 - \epsilon} G(\boldsymbol{x}_1, \boldsymbol{x})\boldsymbol{J}_1(\boldsymbol{x}_1)dV \tag{175}$$

where $\boldsymbol{x} \in V_1$. We have to make a hole ϵ at the position $\boldsymbol{x}$. The radio of the hole is r_ϵ, The field is the contribution of all other charges without the charge at x. The field can only be defined on the place there is a charge. Here $G(\boldsymbol{x}, \boldsymbol{x}_2)$ is the green function.

One thing is $G(\boldsymbol{x}, \boldsymbol{x})$ is with infinity divergence. It take a hole ϵ is easy accept. But normally we will think outside the region V_1, the electric field at any position $\boldsymbol{x}_2$ can be written as Eq.(174) even J_2 do not exist. This is wrong. The field definition is only correct on the charges or current distribution.

Hence superposition principle is established only on the place where is a charge or current. Hence the total field can be defined as following,

$$\boldsymbol{E}(\boldsymbol{x}) = [\boldsymbol{E}(\boldsymbol{x}_1, \boldsymbol{x}), \boldsymbol{E}(\boldsymbol{x}_2, \boldsymbol{x}), ..., \boldsymbol{E}(\boldsymbol{x}_N, \boldsymbol{x})] \tag{176}$$

Where $\boldsymbol{x}$ is at any position, where there is no charge. The flowing definition of field,

$$\boldsymbol{E}(\boldsymbol{x}) = \sum_{j=1}^{N} \boldsymbol{E}(\boldsymbol{x}_j, \boldsymbol{x}) \tag{177}$$

We have shown that is will over estimate the energy from the above formula.

If there is a charge in the position $\boldsymbol{x_i}$ there is the following superposition formula,

$$\boldsymbol{E}(\boldsymbol{x}_i) = \sum_{j=1, j \neq = i}^{N} \boldsymbol{E}(\boldsymbol{x}_j, \boldsymbol{x}_i) \tag{178}$$

The above is still Ok. Hence if there are N charges, in any place with the charge the superposed field is always the superposition of other $N-1$ charge. If in the place without charge we applied the Eq.(176) as the definition of the field with N charges. If N is small for example $N = 2$. There is only 2 charges, hence, calculate Eq.(178) only use one charge, but Eq.(177) use 2 charges to calculate fields. In the case of two charge, there is big difference between Eq.(177) and Eq.(178).

In the future we still can apply Eq.(178) to calculate the field on the charges. We can use Eq.(178) to define the field at any place without charge. In this place even the charge cannot be superposed, we still can calculate energy with mutual energy principle in which the sigma sign $\sum_{j=1,j\neq=i}^{N}$ is appear.

The reason the superposition principle of Eq.(177) is wrong, is it lead the wrong system power,

$$P=\sum_{i=1}^{N}\sum_{j=1}^{N}\boldsymbol{E}(\boldsymbol{x}_j,\boldsymbol{x}_i)\cdot\boldsymbol{I}_i \tag{179}$$

The correct power is,

$$P=\sum_{i=1}^{N}\sum_{j=1,j\neq i}^{N}\boldsymbol{E}(\boldsymbol{x}_j,\boldsymbol{x}_i)\cdot\boldsymbol{I}_i \tag{180}$$

And the superposition principle also lead to the wrong energy flow in Poynting equation,

$$-\oiint_{\Gamma}(\sum_{i=1}^{N}\sum_{j=1}^{N}\boldsymbol{E}_i\times\boldsymbol{H}_j)\cdot\hat{n}d\Gamma$$
$$=\iiint_V\sum_{i=1}^{N}\sum_{j=1}^{N}(\boldsymbol{E}_i\cdot\boldsymbol{J}_j)dV$$
$$+\iiint_V\sum_{i=1}^{N}\sum_{j=1}^{N}(\boldsymbol{E}_i\cdot\partial\boldsymbol{D}_j+\boldsymbol{H}_i\cdot\partial\boldsymbol{B}_j)dV \tag{181}$$

The correct formula should be,

$$-\oiint_{\Gamma}(\sum_{i=1}^{N}\sum_{j=1,j\neq i}^{N}\boldsymbol{E}_i\times\boldsymbol{H}_j)\cdot\hat{n}d\Gamma$$
$$=\iiint_V\sum_{i=1}^{N}\sum_{j=1,j\neq i}^{N}(\boldsymbol{E}_i\cdot\boldsymbol{J}_j)dV$$
$$+\iiint_V\sum_{i=1}^{N}\sum_{j=1,j\neq i}^{N}(\boldsymbol{E}_i\cdot\partial\boldsymbol{D}_j+\boldsymbol{H}_i\cdot\partial\boldsymbol{B}_j)dV \tag{182}$$

Hence for the place there is no any charge, the field cannot be superposed it will be written as Eq.(176), we can only calculate the energy from the above mutual energy formula.

Summary the field can be defined as following,

$$\boldsymbol{E}(\boldsymbol{x})=\begin{cases}[\boldsymbol{E}(\boldsymbol{x}_1,\boldsymbol{x}),\boldsymbol{E}(\boldsymbol{x}_2,\boldsymbol{x}),......,\boldsymbol{E}(\boldsymbol{x}_N,\boldsymbol{x})] & \boldsymbol{x}\notin X\\ \sum_{j=1,j\neq i}^{N}\boldsymbol{E}(\boldsymbol{x}_i,\boldsymbol{x}) & \boldsymbol{x}=\boldsymbol{x}_i\in X\end{cases} \tag{183}$$

where X is the set of $x_1, x_2 \ldots x_N$, which is the position of electric charges. Similar we define the magnetic field as,

$$\boldsymbol{H}(\boldsymbol{x}) = \begin{cases} [\boldsymbol{H}(\boldsymbol{x}_1, \boldsymbol{x}), \boldsymbol{H}(\boldsymbol{x}_2, \boldsymbol{x}), ..., \boldsymbol{H}(\boldsymbol{x}_N, \boldsymbol{x})] & \boldsymbol{x} \notin X \\ \sum_{j=1, j\neq i}^{N} \boldsymbol{H}(\boldsymbol{x}_i, \boldsymbol{x}) & \boldsymbol{x} = \boldsymbol{x}_i \in X \end{cases} \tag{184}$$

For the radiation filed, if $x \in V_1$,

$$E(\boldsymbol{x}) = \lim_{r_\epsilon \to 0} \iiint\limits_{V_1 - \epsilon} G_E(\boldsymbol{x}_1, \boldsymbol{x}) \boldsymbol{J}_1(\boldsymbol{x}_1) dV \tag{185}$$

$$H(\boldsymbol{x}) = \lim_{r_\epsilon \to 0} \iiint\limits_{V_1 - \epsilon} G_H(\boldsymbol{x}_1, \boldsymbol{x}) \boldsymbol{J}_1(\boldsymbol{x}_1) dV \tag{186}$$

Where $G_E(\boldsymbol{x}_i, \boldsymbol{x})$ and $G_H(\boldsymbol{x}_i, \boldsymbol{x})$ are Green function for the radiation filed of charge at the position $\boldsymbol{x}_i.r_\epsilon$ is the small sphere region, the radius is r_ϵ. Here the green function is possible as retarded field or advanced field depending if it is emitter or absorber. However in the practice problem the emitters are separated with absorbers. For example the absorber are all at the infinite big sphere.

If $x \notin V_1$, it still can define the field as, following,

$$E(\boldsymbol{x}) = \iiint\limits_{V_1} G_E(\boldsymbol{x}_1, \boldsymbol{x}) \boldsymbol{J}_1(\boldsymbol{x}_1) dV \tag{187}$$

$$H(\boldsymbol{x}) = \iiint\limits_{V_1} G_H(\boldsymbol{x}_1, \boldsymbol{x}) \boldsymbol{J}_1(\boldsymbol{x}_1) dV \tag{188}$$

But we should notice, this is not a real field, it is only the field in case there is a charge at the position $\boldsymbol{x}$. We cannot apply this field to calculate related energy, energy flow relating to Poynting vector and Poynting theorem. It can be applied to calculate the mutual energy items and mutual energy flow in mutual energy theorem.

This is also the reason the author claim that there is a bug in Poynting theorem. It is clear the Poynting theorem cannot be proved by the mutual energy principle. If we have use the mutual energy principle as axiom of the electromagnetic field theory. Poynting theorem should be rule out. At least know the problem of Poynting theorem. Let us looks the following mutual energy theorem,

$$-\int\limits_{t=-\infty}^{\infty} \iiint\limits_{V_1} \boldsymbol{E}_2 \cdot \boldsymbol{J}_1 dV dt = Q = \int\limits_{t=-\infty}^{\infty} \iiint\limits_{V_2} \boldsymbol{E}_1 \cdot \boldsymbol{J}_2 dV dt$$

$\boldsymbol{E}_2$ is calculated at the position V_1, where is outside of the position the current $\boldsymbol{J}_2$, which is V_2. In the position $x_1 \in V_1$, E_2 is calculated by a supposition on V_2, that is no any problem, because V_2 is outside of V_1.

It is same E_1 is calculated at V_2 which is at outside of the position of V_1. The superposition on $V_1$to get E_1 is also no problem. About the mutual energy flow,

$$Q=(\xi_1,\xi_2)=\int\limits_{t=-\infty}^{\infty}\oiint\limits_{\Gamma}\cdot(\boldsymbol{E}_1\times\boldsymbol{H}_2+\boldsymbol{E}_2\times\boldsymbol{H}_1)\cdot\hat{n}d\Gamma dt$$

It can be calculate outside $V_1$and V_2. Γ is a surface between V_2 and V_2. We have side that the field can be defined only if there is a charge. Actually the field is also can be defined outside the region where there is a charge. In the above situation the field can be defined also on the place of Γ which is outside of the charge place V_1, V_2. The point is in the above formula we calculate the mutual energy, instead of the Poynting energy.

Hence, the point is superposition is not correct, If in a space $\boldsymbol{x}$ there is no any charge, you calculate the field of this position according to the superposition principle, and then calculate the energy according the Poynting theorem, you got a wrong result.

In other hand if you use mutual energy principle to calculate the energy in the space, the superposition principle can still be used. Actually when you use superposition principle and mutual energy theorem to calculate energy, actually you have applied the self-energy principle and mutual energy principle which guarantees you get a correct energy result.

Since we have the self-energy principle, the superposition is correct again, the place the field can be correct defined is the place exclude all charge positions. In the place outside of all charge positions the mutual energy can still be corrected defined.

12 How macroscopic wave is produced by infinite particle-wave of photons?

Assume macroscopic wave for example the wireless wave which is still satisfied the Maxwell equation very good. The theory of the mutual energy principle and the self-energy principle actually offers a theory of particle-wave for photon. It can very good described the energy conservation and moment conservation of the photon. However we will ask whether or not this particle wave for the photon can support the macroscopic wave of the Maxwell equations? If there is supposition principle, the answer is clear, yes. However from last a few sections we have known that the superposition principle is not an accurate principle. Superposition principle with SCMEQ conflict with energy conservation law. Superposition is only can be done is some situations.

The author believe the wrong is ether at the supposition principle or at the SCMEQ. Later we have proved SCMEQ is at least partially correct (in the time the retarded wave and the advanced wave are synchronized). Hence the only possible wrong is at the superposition principle. Superposition can be done only at the place where there is a charge or an absorber. And in the place of charge, or absorber the field contribution of that charge must take a way. This correct definition is quit different with the tradition way of definition for superposition. Hence we cannot directly obtained the Macroscopic wave equations by using the superposition.

If superposition principle is wrong we cannot obtained MCMEQ from SCMEQ easily. However we know that in the low frequency bound for example in the wireless frequency bound the theory of Maxwell equation is still very good which has been successfully applied for thousands applications. Now the axioms of the the author's new electromagnetic theory are the mutual energy principle and the self-energy principle, we have to prove the MCMEQ from the the mutual energy principle and self-energy principle. And we must avoid to apply the superposition principle.

We also said that the mutual energy principle and self-mutual energy principle are equation for photon, hence our task is build macroscopic wave from the waves of infinite more photons. This is a process to build macroscopic law from the microscopic law.

Assume the absorbers are uniformed distribute at the infinite big sphere. The absorbers sends the advanced wave which can be described as,

$$\boldsymbol{E}_2=\sum_{i=1}^{N}\boldsymbol{E}_{2i} \tag{189}$$

$$\boldsymbol{H}_2=\sum_{i=1}^{N}\boldsymbol{H}_{2i} \tag{190}$$

Here we have superposed the advanced fields, this field is acted at the emitter. Here emitter will play the role of test charge. The contribution by the absorber to the place at the emitter can be superposed. It should be noticed, that in the place of emitter, there is a charge, we have said if there is a charge, the field still can be superposed. Especially we superpose the field ξ_2 which are at outside of the region V_2, this field will have not the problem to be superposed.

Assume the emitter is sited at the center of the infinite big sphere. We take this center as the origin of the coordinates. The retarded field are $\boldsymbol{E}_1$. Assume $\boldsymbol{J}_1$ is the current of the emitter. $\boldsymbol{J}_{2i}$ are the source of absorber. The mutual energy principle for this system can be written as,

$$-\oint\!\!\!\oint_{\Gamma}(\boldsymbol{E}_1\times\boldsymbol{H}_{2i}+\boldsymbol{E}_{2i}\times\boldsymbol{H}_1)\cdot\hat{n}d\Gamma=\iiint_V(\boldsymbol{E}_{2i}\cdot\boldsymbol{J}_1+\boldsymbol{E}_1\cdot\boldsymbol{J}_{2i})dV$$

$$+\iiint_V(\boldsymbol{E}_1\cdot\partial\boldsymbol{D}_{2i}+\boldsymbol{E}_{2i}\cdot\partial\boldsymbol{D}_1+\boldsymbol{H}_1\cdot\partial\boldsymbol{B}_{2i}+\boldsymbol{H}_{2i}\cdot\partial\boldsymbol{B}_1)dV \tag{191}$$

Consider the superposition principle is still OK for there is the charges. In this situation the test charge is the emitter. Because there is the emitter the superposed field is OK.

$$-\oiint_{\Gamma}(\boldsymbol{E}_1\times\boldsymbol{H}_2+\boldsymbol{E}_2\times\boldsymbol{H}_1)\cdot\hat{n}d\Gamma=\iiint_V(\boldsymbol{E}_2\cdot\boldsymbol{J}_1+\boldsymbol{E}_1\cdot\boldsymbol{J}_2)dV$$

$$+\iiint_V(\boldsymbol{E}_1\cdot\partial\boldsymbol{D}_2+\boldsymbol{E}_2\cdot\partial\boldsymbol{D}_1+\boldsymbol{H}_1\cdot\partial\boldsymbol{B}_2+\boldsymbol{H}_2\cdot\partial\boldsymbol{B}_1)dV \qquad (192)$$

Where $\xi_2=[\boldsymbol{E}_2,\boldsymbol{H}_2]$ are given by the Eq.(189,190). For the above formula the volume V can be arbitrary. We take the V as the V_1, the above equation can be rewritten as,

$$-\oiint_{\Gamma_1}(\boldsymbol{E}_1\times\boldsymbol{H}_2+\boldsymbol{E}_2\times\boldsymbol{H}_1)\cdot\hat{n}d\Gamma=\iiint_{V_1}\boldsymbol{E}_2\cdot\boldsymbol{J}_1dV$$

$$+\iiint_{V_1}(\boldsymbol{E}_1\cdot\partial\boldsymbol{D}_2+\boldsymbol{E}_2\cdot\partial\boldsymbol{D}_1+\boldsymbol{H}_1\cdot\partial\boldsymbol{B}_2+\boldsymbol{H}_2\cdot\partial\boldsymbol{B}_1)dV \qquad (193)$$

where Γ_1 is the boundary of the V_1. Since $\boldsymbol{E}_2$ is from all direction it is should be looks like $\boldsymbol{E}_1$, hence we can assume

$$\boldsymbol{E}_2=k\boldsymbol{E}_1 \qquad (194)$$

$$\boldsymbol{H}_2=k\boldsymbol{H}_1 \qquad (195)$$

Substitute the above equation to

$$-k\oiint_{\Gamma_1}(\boldsymbol{E}_1\times\boldsymbol{H}_1+\boldsymbol{E}_1\times\boldsymbol{H}_1)\cdot\hat{n}d\Gamma=k\iiint_{V_1}\boldsymbol{E}_1\cdot\boldsymbol{J}_1dV$$

$$+k\iiint_{V_1}(\boldsymbol{E}_1\cdot\partial\boldsymbol{D}_1+\boldsymbol{E}_1\cdot\partial\boldsymbol{D}_1+\boldsymbol{H}_1\cdot\partial\boldsymbol{B}_1+\boldsymbol{H}_1\cdot\partial\boldsymbol{B}_1)dV \qquad (196)$$

We have found that k has no any effect to the above formula, because it will take place in the two side of the equal sign. Or,

$$-2\oiint_{\Gamma_1}\boldsymbol{E}_1\times\boldsymbol{H}_1\cdot\hat{n}d\Gamma=\iiint_{V_1}\boldsymbol{E}_1\cdot\boldsymbol{J}_1dV$$

$$+2\iiint_{V_1}(\boldsymbol{E}_1\cdot\partial\boldsymbol{D}_1+\boldsymbol{H}_1\cdot\partial\boldsymbol{B}_1)dV \qquad (197)$$

We find this is very close the to the Poynting theorem. The only different is the fact of 2. This fact come because we have made some wrong in some where.

12.1 Found the reason the fact 2 can be take away

There are few reasons this fact 2 can be take away.

(1) $\boldsymbol{E}_2$ in the Eq.(193) has some difference compare to $\boldsymbol{E}_1$ in Eq.(197). $\boldsymbol{E}_1$ is a field has single point at the charge q_1 position $\boldsymbol{x}_1$. $\boldsymbol{E}_1$ has different direction at the charge q_1. In other hand, $\boldsymbol{E}_2$ has no any single point at $\boldsymbol{x}_1$, it is same have only one direction at x_1. Hence, $\boldsymbol{E}_1$ cannot act fully at the current $\boldsymbol{J}_1$. It is possible that the value,

$$\iiint_{V_1} \boldsymbol{E}_1 \cdot \boldsymbol{J}_1 dV < \iiint_{V_1} \boldsymbol{E}_2 \cdot \boldsymbol{J}_1 dV$$

This lead us when use $\iiint_{V_1} \boldsymbol{E}_1 \cdot \boldsymbol{J}_1 dV$ to replace $\iiint_{V_1} \boldsymbol{E}_2 \cdot \boldsymbol{J}_1 dV$, we need to use,

$$\iiint_{V_1} \boldsymbol{E}_2 \cdot \boldsymbol{J}_1 dV \Leftarrow 2 \iiint_{V_1} \boldsymbol{E}_1 \cdot \boldsymbol{J}_1 dV$$

This way we will obtain the fact 2. The formula Eq.(197) should be replaced as,

$$-\oint\!\!\!\oint_{\Gamma_1} \boldsymbol{E}_1 \times \boldsymbol{H}_1 \cdot \hat{n} d\Gamma = \iiint_{V_1} \boldsymbol{E}_1 \cdot \boldsymbol{J}_1 dV + \iiint_{V_1} (\boldsymbol{E}_1 \cdot \partial \boldsymbol{D}_1 + \boldsymbol{H}_1 \cdot \partial \boldsymbol{B}_1) dV \quad (198)$$

Which is the Poynting theorem.

(2) First we find for mutual energy principle Eq.(191) the shape of the vector

$$\boldsymbol{S}_{12i} = \boldsymbol{E}_1 \times \boldsymbol{H}_{2i} + \boldsymbol{E}_{2i} \times \boldsymbol{H}_1 \quad (199)$$

is different with the Poynting vector

$$\boldsymbol{S} = \boldsymbol{E}_1 \times \boldsymbol{H}_1 \quad (200)$$

The shape of $\boldsymbol{S}$ is close to a uniformed distribution at all directions. But $\boldsymbol{S}_{12i}$ has maximum at the direction of the absorber "$2i$". And has minimum at the direction of the opposite direction. Hence, I guess that the two items $\boldsymbol{E}_1 \times \boldsymbol{H}_{2i} + \boldsymbol{E}_{2i} \times \boldsymbol{H}_1$ of the mutual energy only equal one items of Poynting vector $\boldsymbol{S} = \boldsymbol{E}_1 \times \boldsymbol{H}_1$, We mean,

$$\oint\!\!\!\oint_{\Gamma_1} (\boldsymbol{E}_1 \times \boldsymbol{H}_1) \cdot \hat{n} d\Gamma \Leftarrow \oint\!\!\!\oint_{\Gamma_1} (\boldsymbol{E}_1 \times \boldsymbol{H}_{2i} + \boldsymbol{E}_{2i} \times \boldsymbol{H}_1) \cdot \hat{n} d\Gamma \quad (201)$$

From this we can obtained the the fact 2. In the above discussion we have not consider this. If we consider this, the problem of fact 2 is gone.

It is similar, there should be,

$$\boldsymbol{E}_1\cdot\partial\boldsymbol{D}_1+\boldsymbol{H}_1\cdot\partial\boldsymbol{B}_1 \Leftarrow (\boldsymbol{E}_1\cdot\partial\boldsymbol{D}_{2i}+\boldsymbol{E}_{2i}\cdot\partial\boldsymbol{D}_1+\boldsymbol{H}_1\cdot\partial\boldsymbol{B}_{2i}+\boldsymbol{H}_{2i}\cdot\partial\boldsymbol{B}_1) \quad (202)$$

hence we have times $\frac{1}{2}$ to left side of formula Eq.(197), hence we have,

$$-\oiint_{\Gamma_1} \boldsymbol{E}_1\times\boldsymbol{H}_1\cdot\hat{n}d\Gamma = \iiint_{V_1} \boldsymbol{E}_1\cdot\boldsymbol{J}_1 dV + \iiint_{V_1}(\boldsymbol{E}_1\cdot\partial\boldsymbol{D}_1+\boldsymbol{H}_1\cdot\partial\boldsymbol{B}_1)dV \quad (203)$$

This is Poynting theorem.

(3) We have made a wrong calculation of the field,

The correction should be

$$E_{1new} = \frac{1}{2}E_1 \quad (204)$$

Substitute this to Eq.(197) we have,

$$-\oiint_{\Gamma_1} \boldsymbol{E}_{1new}\times\boldsymbol{H}_{1new}\cdot\hat{n}d\Gamma = \iiint_{V_1} \boldsymbol{E}_{1new}\cdot\boldsymbol{J}_1 dV + \iiint_{V_1}(\boldsymbol{E}_{1new}\cdot\partial\boldsymbol{D}_{1new}+\boldsymbol{H}_{1new}\cdot\partial\boldsymbol{B}_{1new})dV \quad (205)$$

Equation Eq(204) is sames as the half potential defined in the Wheeler-Feynman absorber theory[1].

In the subsection 10.4 we have know that the Maxwell equation is still correct in the sense of probability. If it correct in probability, the Poynting theorem should also correct in the sense of probability. If there are more absorbers, the absorbers are full distribute at the infinite big sphere, then the Maxwell equation and Poynting theorem will be established. In the above 3 guesses (1), (2) and (3), the author fell the (3) is more correct.

12.2 Consider if $\boldsymbol{J}_1$ is a distribution instead of only one charge

It is noticed that for this Poynting theorem we need the absorber. And the absorbers must be uniformed distributed at the infinite big sphere. We have proved the Poynting theorem in which the emitter source is at the center of the infinite big sphere. We can also prove that even The current $\boldsymbol{J}_1$ is distribute in a region V_1 close to the origin. In this situation the Poynting theorem is also established.

The reason is that we know that the mutual energy theorem is established to,

$$-\oiint_{\Gamma_1}(\boldsymbol{E}_{1j}\times\boldsymbol{H}_{2i}+\boldsymbol{E}_{2i}\times\boldsymbol{H}_{1j})\cdot\hat{n}d\Gamma=\iiint_{V_1}\boldsymbol{E}_{2i}\cdot\boldsymbol{J}_{1j}dV$$

$$+\iiint_{V_1}(\boldsymbol{E}_{1j}\cdot\partial\boldsymbol{D}_{2i}+\boldsymbol{E}_{2i}\cdot\partial\boldsymbol{D}_{1j}+\boldsymbol{H}_1\cdot\partial\boldsymbol{B}_{2i}+\boldsymbol{H}_{2i}\cdot\partial\boldsymbol{B}_{1j})dV \tag{206}$$

Since $\boldsymbol{J}_{1j}$ is inside V_1, $\boldsymbol{J}_{2j}$ is at inside of V_2. For this situation the field $\boldsymbol{E}_{1i}$ can be superposed.

$$\boldsymbol{E}_1=\sum_{i=1}^{N}\boldsymbol{E}_{1i} \tag{207}$$

$$\boldsymbol{H}_1=\sum_{i=1}^{N}\boldsymbol{H}_{1i} \tag{208}$$

We obtained the mutual energy principle.

$$-\oiint_{\Gamma}(\boldsymbol{E}_1\times\boldsymbol{H}_{2i}+\boldsymbol{E}_{2i}\times\boldsymbol{H}_1)\cdot\hat{n}d\Gamma=\iiint_{V}(\boldsymbol{E}_{2i}\cdot\boldsymbol{J}_1+\boldsymbol{E}_1\cdot\boldsymbol{J}_{2i})dV$$

$$+\iiint_{V}(\boldsymbol{E}_1\cdot\partial\boldsymbol{D}_{2i}+\boldsymbol{E}_{2i}\cdot\partial\boldsymbol{D}_1+\boldsymbol{H}_1\cdot\partial\boldsymbol{B}_{2i}+\boldsymbol{H}_{2i}\cdot\partial\boldsymbol{B}_1)dV \tag{209}$$

Similar as before we obtained the Poynting theorem Eq.(206).

12.3 Proving Poynting theory in wave guide

In the wave guide, the electromagnetic field is one dimension. In the traditional electromagnetic field theory we only assume that the electromagnetic field is produced by transmitter in the wave guide. In the author's new theory the receiver inside the the wave guide will also produce electromagnetic field. The transmitter will produce the retarded field, the receiver will produce the advanced field. Since in the wave guide the electromagnetic field is one dimension, it is not attenuated. In this situation the advanced field is exactly same as the retarded wave. Both retarded wave and advanced wave each has half the traditional field. Please see 8.

$$\boldsymbol{E}_1=\boldsymbol{E}_2=\frac{1}{2}\boldsymbol{E} \tag{210}$$

$$\boldsymbol{H}_1=\boldsymbol{H}_2=\frac{1}{2}\boldsymbol{H} \tag{211}$$

where $\boldsymbol{E}$,$\boldsymbol{H}$ are traditional electromagnetic fields. $\boldsymbol{E}_1$, $\boldsymbol{H}_1$ are the retarded wave. $\boldsymbol{E}_2$, $\boldsymbol{H}_2$ are the advanced wave.

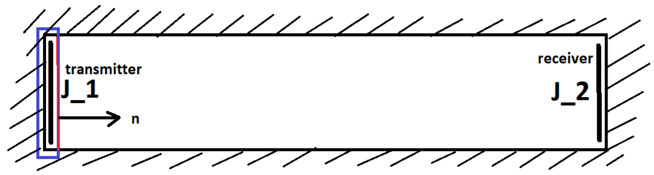

Figure 8: This is a wave guide, in the left end, there is a transmitter. In the right end there is a receiver. V_1 is the volume of the current $\boldsymbol{J}_1$. We take a close surface surrounding the volume V_1. Since the electric field on the wave guide wall are 0. The only non-zero surface is at the front of the volume V_1.See the red line. The surface integral is nonzero only on the front of the V_1.

In the wave guide if we take a close surface include the transmitter, since the electric field are 0 at the wall of the wave guide. The electric field nonzero only on the front of the transmitter, hence the Poynting theorem tell us,

$$\iint\limits_{\boldsymbol{S}} \boldsymbol{E} \times \boldsymbol{H}^* \cdot \hat{n} dS = \iiint\limits_{V_1} \boldsymbol{J_1} \cdot \boldsymbol{E}^* dS \tag{212}$$

Where V_1 is the volume of the transmitter. S is the surface in front of the transmitter inside the wave guide. $\boldsymbol{J}_1$ is the current on the volume V_1, $\boldsymbol{E}_1$ is the traditional electric field inside the wave guide. $\hat{n}$ is normal vector of the surface S. We the surface S is hugged on volume V_1, hence we do not need to consider the saved energy in the volume V_1.

If we apply the mutual energy theorem to the transmitter V_1, we obtained,

$$\iiint\limits_{V_1} \boldsymbol{J_1} \cdot \boldsymbol{E_2^*} dS = \iint\limits_{S} (\boldsymbol{E_1} \times \boldsymbol{H_2^*} + \boldsymbol{E_2^*} \times \boldsymbol{H_1}) \cdot \hat{n} dS \tag{213}$$

or

$$\iiint\limits_{V_1} \boldsymbol{J_1} \cdot \boldsymbol{\frac{1}{2}} \boldsymbol{E}^* dS = \iint\limits_{S} (\frac{1}{2}\boldsymbol{E} \times \frac{1}{2}\boldsymbol{H}^* + \boldsymbol{\frac{1}{2}}\boldsymbol{E}^* \times \boldsymbol{\frac{1}{2}}\boldsymbol{H}) \cdot \hat{n} dS \tag{214}$$

or

$$\iint\limits_{S_1} \boldsymbol{J_1} \cdot \boldsymbol{E}^* dS = \Re \iint\limits_{\boldsymbol{S}} (\boldsymbol{E} \times \boldsymbol{H}^*) \cdot \hat{n} dS \tag{215}$$

Where $\Re$ is taken the real part of a complex number. The real part of the above formula is same as the Poynting theorem Eq.(212).

12.4 The Maxwell equations should also be established in Macroscopic situation

If the Poynting theorem for the macroscopic wave is established. We can say that the Maxwell equation of macroscopic situation also should be established. The reason is we can derived the Poynting theorem from the Maxwell equation. Hence if we would to find solution of Poynting theorem, the solution of Maxwell equations are the solution of Poynting theorem. We cannot prove the Maxwell equations from the Poynting theorem. However we can derive from Poynting theorem the mutual energy theorem. From mutual energy theorem we can got the Green function solution of the Maxwell equations. From all the solution of the Maxwell equations we can obtained the Maxwell equations inductively.

In this section all the proof are only in spiritual, it is not strictness.

13 Different superpositions

There are different superposition. For example if 2 identical wave are superposed, two waves in double slits, a photon's waves which are one retarded wave and one advanced wave.

(1) Tow identical retarded wave are superposed. For example there are two transmitting wireless antennas. Each antenna has a fixed current. In this situation we assume that the sources are exact same and are put in the same place. This is the case $1+1 \to 4$, here $1+1$ means there two identical fields are superposed. $\to 4$ means the power of the superposed field are 4 times larger as if one wave along.

In this situation, the superposed field are

$$\boldsymbol{E} = E_1 + E_2 \tag{216}$$

$$H = H_1 + H_2 \tag{217}$$

The Poynting vector are

$$\boldsymbol{E} \times \boldsymbol{H} = (E_1 + E_2) \times (H_1 + H_2)$$

$$= E_1 \times H_1 + E_2 \times H_2 + E_1 \times H_2 + E_2 \times H_1 \tag{218}$$

Where $E_1 \times H_1 + E_2 \times H_2$ is corresponding to two self-energy items. $E_2 \times H_2 + E_1 \times H_2$ corresponding the mutual energy items. In the above most time we are talk about the mutual energy, the mutual energy flow of a retarded wave and an advanced wave. But the mutual energy, mutual energy flow also can be for two retarded waves and also two advanced waves. We assume this two sources are macroscopic waves, since in this case the Poynting theorem still can be established with the condition there exist infinite absorbers on the infinite big sphere.

$$-\oiint_{\Gamma}(\boldsymbol{E}_i\times\boldsymbol{H}_i)\cdot\hat{n}d\Gamma=\iiint_V(\boldsymbol{E}_i\cdot\boldsymbol{J}_i)dV$$

$$+\iiint_V(\boldsymbol{E}_i\cdot\partial\boldsymbol{D}_i+\boldsymbol{H}_i\cdot\partial\boldsymbol{B}_i)dV \qquad i=1,2 \tag{219}$$

Since $i-1,2$, This contributed 2 times of power.

The mutual energy part of energy are:

$$-\oiint_{\Gamma}(\boldsymbol{E}_1\times\boldsymbol{H}_2+\boldsymbol{E}_2\times\boldsymbol{H}_1)\cdot\hat{n}d\Gamma$$

$$=\iiint_V(\boldsymbol{E}_1\cdot\boldsymbol{J}_2+\boldsymbol{E}_2\cdot\boldsymbol{J}_1)dV$$

$$+\iiint_V(\boldsymbol{E}_1\cdot\partial\boldsymbol{D}_2+\boldsymbol{H}_2\cdot\partial\boldsymbol{B}_1+\boldsymbol{E}_2\cdot\partial\boldsymbol{D}_1+\boldsymbol{H}_1\cdot\partial\boldsymbol{B}_2)dV \tag{220}$$

Since the two fields are identical, the above formula can be written as,

$$-2\oiint_{\Gamma}(\boldsymbol{E}_1\times\boldsymbol{H}_1)\cdot\hat{n}d\Gamma$$

$$=2\iiint_V(\boldsymbol{E}_1\cdot\boldsymbol{J}_1)dV$$

$$+2\iiint_V(\boldsymbol{E}_1\cdot\partial\boldsymbol{D}_1+\boldsymbol{H}_1\cdot\partial\boldsymbol{B}_1)dV \tag{221}$$

This part also offers also 2 times of power. The total power include the self-energy flows are 4 times large. The reason power output are 4 times are because the field $\boldsymbol{E}_1$ also act at the source $\boldsymbol{J}_2$, see the item $\boldsymbol{E}_1\cdot\boldsymbol{J}_2$. Which will force the antenna 2 supply 1 times more power. Similarly in the the antenna 1 also supply double power. Together the two antenna supply 4 times more power as one antenna.

Actually, it is very clear, even there is only one antenna, if we double the current, the power will be 4 times large, since the output resistant are fixed. We know the output resistant is only dependent to the shape of the antenna.

(2) $1+1\to 2$ If same as the above situation but the two sources (two wireless antennas) are separated with a distance. In this situation the coupling of two antenna are decreased, if

$$\iiint_V(\boldsymbol{E}_1\cdot\boldsymbol{J}_2+\boldsymbol{E}_2\cdot\boldsymbol{J}_1)dV\to 0 \tag{222}$$

then

$$\oiint_{\Gamma} (\boldsymbol{E}_1 \times \boldsymbol{H}_2 + \boldsymbol{E}_2 \times \boldsymbol{H}_1) \cdot \hat{n} d\Gamma \to 0 \tag{223}$$

In this situation, the two antenna have the output power only two times as one antenna working alone.

For example if our antenna has sharp directivity diagram, for example it is microwave plate antenna, even they are separated only a short distance, the coupling of the two antenna or beam are close to 0. It is similar as two laser beams, since the laser beam has very sharp directivity diagram. The two laser beam sources are only separate 1 millimeter, but actually they are separate thousand wave lengths. They are well separated. The sources has not coupling together. The source cannot offer more power through the coupling items: $\iiint_V (\boldsymbol{E}_1 \cdot \boldsymbol{J}_2 + \boldsymbol{E}_2 \cdot \boldsymbol{J}_1) dV$. In this case there is only $1 + 1 = 2$.

(3) $1 + 1 \to 1$ There is a retarded wave sent from emitter and there is a advanced wave send from absorber. Assume the retarded wave and the advanced wave are superposed and the mutual energy are produced from this superposition. According to the self-energy principle that the two self-energy flows are returned through the two time-reverse processes which do not satisfies Maxwell equations but satisfies the time-reversal Maxwell equations. Hence the self-energy flow do not have any contributions for the energy transferring from the emitter to the absorber. The energy transfer from emitter to the absorber is only been done by the mutual energy flow. The mutual energy flow is responsible to send the energy of one photon from the emitter to the absorber. After the mutual energy flow sending the energy from emitter to the absorber, the self-energy flow for the retarded wave returns from the whole space back to the emitter. The self-energy flow for the advanced wave returns from the whole space back to the absorber. Self-energy flow do not involved in the energy transfer. The part of energy in the retarded wave which is received by the absorber is one photon. The absorber received only one photon. We can written this as $1 + 1 \to 1$, this means one retarded wave plus one advanced wave equal to one photon. It is not a process with$1 + 1 \to 4$ or $1 + 1 \to 2$ but $1 + 1 \to 1$.

(3) $1 + 1 \to 0$

The superposition of the wave and its corresponding time-reversal wave are thoroughly balance out or canceled, which means that $1 + 1 \to 0$. The total energy flow after the superposition is 0 for this situation.

14 Reciprocity theorem

14.1 The mutual energy theorem can be used as reciprocity theorem

We have know the mutual energy theorem can be written as,

$$-(\tau_1, \xi_2) = (\xi_1, \xi_2) = (\xi_1, \tau_2) \tag{224}$$

$$\xi_1 = M_1\tau_1 \tag{225}$$

$$\xi_2 = M_2\tau_2 \tag{226}$$

$$-(\tau_1, M_2\tau_2) = (\xi_1, \xi_2) = (M_1\tau_1, \tau_2) \tag{227}$$

When we use this theorem as reciprocity theorem, we will make conjugate transform to all the fields that means

$$\boldsymbol{C}\xi_1 = \boldsymbol{C}(M_1\tau_1) \tag{228}$$

$$\boldsymbol{C}\xi_2 = \boldsymbol{C}(M_2\tau_2) \tag{229}$$

In this article the conjugate transform is introduced by subsection 7.5.

$$-(\boldsymbol{C}\tau_1, \boldsymbol{C}M_2\tau_2) = (\boldsymbol{C}\xi_1, \boldsymbol{C}\xi_2) = (\boldsymbol{C}M_1\boldsymbol{C}\tau_1, \boldsymbol{C}\tau_2) \tag{230}$$

or

$$(M_2\tau_2, \tau_1) = (\xi_2, \xi_1) = -(\tau_2, M_1\tau_1) \tag{231}$$

The author did not make the calculation to prove the last step. But this is clear, in the beginning the antenna 1 is transmitting antenna, the antenna 2 is receiving antenna. After make all Conjugate transform, the antenna 2 become the transmitting antenna, the antenna 1 become the receiving antenna. In the above theorem minus sign means the system offering power like electric source. Positive sign means the system use power like the resistance or load. Hence, original in the left side of formula τ_1 is a electric source, τ_2 is a load see Eq.(224), after the conjugate transform τ_2 become the source, τ_1 become the load, see Eq.(231).

This is also the reason that the Welch[31] and de hoop[8] all call this theorem as some kind of reciprocity theorem.

14.2 Lorentz reciprocity theorem

If we make a Conjugate transform to the antenna 2. The equation Eq.(224) becomes

$$-(\tau_1, \boldsymbol{C}\xi_2) = (\xi_1, \boldsymbol{C}\xi_2) = (\xi_1, \boldsymbol{C}\tau_2) \tag{232}$$

or

$$\iiint\limits_{V_1} \boldsymbol{E}_2(\omega) \cdot \boldsymbol{J}_1(\omega) dV = \iiint\limits_{V_2} \boldsymbol{E}_1(\omega) \cdot \boldsymbol{J}_2(\omega) dV \tag{233}$$

It should make clear here, after the conjugate transform to the antenna 2, we obtained the Lorentz reciprocity theorem [3, 4, 5]. Lorentz reciprocity satisfy Maxwell equations but it does not satisfy the mutual energy principle. In Lorentz reciprocity theorem the two electric fields are all retarded waves, we have said that the mutual energy principle need the two fields one is retarded wave and another is advanced wave. Lorentz reciprocity theorem do not satisfy the mutual energy principle but satisfy the Maxwell equations, it still not a physical formula. Lorentz theorem does not describe any energy flow or real physical amount.

Lorentz reciprocity theorem satisfy Maxwell equations but it still not physical equations, also tell us, Maxwell equation is not a physical equation, the real physical equation is the mutual energy principle. Hence up to now we are clear that the mutual energy theorem are real physical theorem, but Lorentz theorem is only mathematical theorem which can be applied to calculate the directivity diagram. Lorentz reciprocity theorem can obtained correct directivity diagram actually is also because the directivity diagram can be calculated by the mutual energy theorem. Since Lorentz reciprocity theorem can obtained same directivity diagram with the mutual energy theorem, hence we can apply the Lorentz reciprocity theorem to calculate the directivity diagram.

We also know that in order to obtained the mutual energy theorem or Lorentz reciprocity theorem we all need to prove that the surface integral on a infinite sphere vanishes. In the proof of mutual energy theorem which is because the two wave one is retarded wave another is advanced wave the two wave cannot reach the infinite big sphere in the same time. Hence this proof is exactly. In contrast, the proof for the integral in the Lorentz reciprocity theorem is much strict. It need is exactly frequency ω. But we know normally our signal are with a frequency bound. Why the Lorentz reciprocity theorem still can obtained correct directivity diagram? The reason is the mutual energy theorem do not need the signal has exact frequency, if one is retarded field another is advanced field that is OK. Since the reciprocity theorem is a transform of the mutual energy theorem, it can also get correct directivity diagram even the frequency is not exact.

14.3 The inverse problem

Assume the Lorentz reciprocity theorem is a correct physical theorem, then we can applied to calculate inverse problem like the following,

$$\boldsymbol{E}_1(\omega) = M_1\boldsymbol{J}_1(\omega) \tag{234}$$

$$\boldsymbol{E}_2(\omega) = M_2\boldsymbol{J}_2(\omega) \tag{235}$$

Substitute Eq.(234,235) to the Lorentz reciprocity theorem Eq.(233) and consider that the integral can be seen as vector inner product we obtains,

$$\boldsymbol{J}_1(\omega)\cdot M_2\boldsymbol{J}_2(\omega) = M_1\boldsymbol{E}_1(\omega)\cdot\boldsymbol{J}_2(\omega) \tag{236}$$

Hence, we can obtained

$$\boldsymbol{J}_1(\omega)M_2\cdot\boldsymbol{J}_2(\omega) = \boldsymbol{J}_2(\omega)M_1\cdot\boldsymbol{J}_1(\omega) \tag{237}$$

or

$$\boldsymbol{J}_1(\omega)M_2\boldsymbol{J}_2(\omega) = \boldsymbol{J}_1(\omega)M_1^T\boldsymbol{J}_2(\omega) \tag{238}$$

or

$$\boldsymbol{J}_1(\omega)(M_2 - M_1^T)\boldsymbol{J}_2(\omega) = 0 \tag{239}$$

or

$$M_2 - M_1^T = 0 \tag{240}$$

or

$$M_2 = M_1^T \tag{241}$$

If the antenna $\boldsymbol{J}_1$ is known, the two antenna is also know that means the M_1 and M_2 also known, we can try to find $\boldsymbol{J}_2(\omega)$ to satisfy the above equation. The question is if we find the solution of $\boldsymbol{J}_2(\omega)$ is the $\boldsymbol{J}_2(\omega)$ the correct answer?

This author believe it is not. The correct answer to find the current should be down with the mutual energy theorem instead of the Lorentz reciprocity theorem. Lorentz reciprocity theorem only can obtained the correct directivity diagram it cannot be applied for the calculation of current distribution.

In order to obtained the current distribution $J_2(\omega)$, the correct method is to apply the mutual energy theorem,

$$-\iiint_{V_1} \boldsymbol{J}_1(\omega) \cdot \boldsymbol{E}_2^*(\omega) dV = \iiint_{V_2} \boldsymbol{J}_2^*(\omega) \cdot \boldsymbol{E}_1(\omega) dV \tag{242}$$

or

$$-\boldsymbol{J}_1(\omega) \cdot M_2^* \boldsymbol{J}_2(\omega)^* = \boldsymbol{J}_2^*(\omega) \cdot M_1 \boldsymbol{J}_1(\omega) \tag{243}$$

or

$$-\boldsymbol{J}_1(\omega) \cdot M_2^* \boldsymbol{J}_2(\omega)^* = \boldsymbol{J}_1(\omega) M_1^T \cdot \boldsymbol{J}_2^*(\omega) \tag{244}$$

considering that $\boldsymbol{J}_1(\omega)$ and $\boldsymbol{J}_2(\omega)$ can be arbitrary then we have,

$$\boldsymbol{J}_1(\omega) \cdot (M_2^* + M_1^T)\boldsymbol{J}_2(\omega)^* = 0 \tag{245}$$

or

$$M_2^* + M_1^T = 0 \tag{246}$$

or

$$M_2 = -M_1^\dagger \tag{247}$$

where

$$M_1^\dagger = (M_1^t)^* \tag{248}$$

15 Action at a distance

15.1 Energy conservation and momentum conservation

We rewritten the mutual energy theorem as following.

$$-\int_{t=-\infty}^{\infty}\iiint_{V_1}(\boldsymbol{E}_2\cdot\boldsymbol{J}_1)$$
$$=Q=$$
$$\int_{t=-\infty}^{\infty}\iiint_{V_2}(\boldsymbol{E}_1\cdot\boldsymbol{J}_2)dV \tag{249}$$

Where

$$Q=\oiint_{\Gamma}(\boldsymbol{E}_1\times\boldsymbol{H}_2+\boldsymbol{E}_2\times\boldsymbol{H}_1)\cdot\hat{n}d\Gamma \tag{250}$$

Where Γ is any complete surface between the volume V_1 and V_2. $\hat{n}$ is surface normal vector, which is chosen at the direction from $V_1$to V_2. $\xi_1=(\boldsymbol{E}_1,\boldsymbol{H}_1)$ is the retarded wave. $\xi_2=(\boldsymbol{E}_2,\boldsymbol{H}_2)$ is the advanced wave. This formula tell us,

Q is not decrease as the field E_1 which is is decrease according to $\frac{1}{r}$, where $r=||\boldsymbol{x}_2-\boldsymbol{x}_1||$.

The energy sucked by the advanced wave from the emitter $\boldsymbol{J}_1$ is

$$-\int_{t=-\infty}^{\infty}\iiint_{V_1}(\boldsymbol{E}_2\cdot\boldsymbol{J}_1) \tag{251}$$

The energy received by the absorber $\boldsymbol{J}_2$ from the retarded wave $\xi_1=(\boldsymbol{E}_1,\boldsymbol{H}_1)$

$$\int_{t=-\infty}^{\infty}\iiint_{V_2}(\boldsymbol{E}_1\cdot\boldsymbol{J}_2)dV \tag{252}$$

The above two energy are equal, The energy received by the absorber equals the energy sent by the emitter. The energy is sent through the mutual energy flow, $\oiint_{\Gamma}(\boldsymbol{E}_1\times\boldsymbol{H}_2+\boldsymbol{E}_2\times\boldsymbol{H}_1)\cdot\hat{n}d\Gamma$ the time integral of the mutual energy flow is the mutual energy which are,Q

$$Q=\int_{t=-\infty}^{\infty}\oiint_{\Gamma}(\boldsymbol{E}_1\times\boldsymbol{H}_2+\boldsymbol{E}_2\times\boldsymbol{H}_1)\cdot\hat{n}d\Gamma \tag{253}$$

Hence we say that this model proved that the photon of the mutual energy flow has the property of energy conservation.

We know that the momentum for the photon is just the energy divided the speed of light. Because the emitter sends the energy at the direction from emitter to the absorber and the absorber receive the energy also at the direction from emitter to the absorber, If energy is conserved in this situation the momentum is also conserved which is $momentum = \frac{Q}{c}$.

We know if we only consider the retarded wave, this energy conservation result cannot realize. Since the retarded wave send energy to the whole space, the most of energy the energy cannot received by the absorber. To solve this problem the concept of the wave function collapse is introduced. However even wave function collapse solved the energy conservation, it still doesn't solve the problem of momentum conservation. This is because the retarded wave is sent to the whole space, in the beginning when the wave is sent out the momentum is 0. When the photon is received by the absorber there is a momentum come from the emitter to the absorber, which is nozero. Hence, the momentum is no conserved.

15.2 The recoil force is done at the time 0

The recoil force of the photon to the emitter is done by,

$$\boldsymbol{E}_2 \cdot \boldsymbol{J}_1 \tag{254}$$

Since $\boldsymbol{E}_2$ is advanced wave, event the action, that is done by $\boldsymbol{E}_1 \cdot \boldsymbol{J}_2$ which need a time T from emitter to move to the absorber, but the since the move time form absorber to emitter by the advanced wave which need a time is $-T$, the total time the emitter obtained the recoil force is at the time,

$$t = T + (-T) = 0 \tag{255}$$

Hence the recoil force is obtained by the emitter at time $t = 0$. This means Even the action of a photon need a time, but the reaction of the photon do not need a time. The photon is actually is the action and the reaction, but for the emitter it fell this action has a immediately recoil force. It is same as the emitter send a bullet out. Hence the emitter will fell there is a photon which is sent out.

It need to be notice that the force of defined as $\boldsymbol{E}_2$, is only can be used to calculate the energy $\boldsymbol{E}_2 \cdot \boldsymbol{J}_1$. The direction of the recoil force on the emitter can only be calculated by the momentum which are

$$P = \frac{Q}{c} = \frac{1}{c} \int_{t=-\frac{T}{2}}^{\frac{T}{2}} \oiint_{\Gamma} (\boldsymbol{E}_1 \times \boldsymbol{H}_2 + \boldsymbol{E}_2 \times \boldsymbol{H}_1) \cdot \hat{n} d\Gamma$$

Where the T is a time of a photon in the emitter. P is the momentum. Which is at the direction from emitter to the absorber. The recoil force can be obtained as,

$$\boldsymbol{F} = -\frac{1}{T} P$$

Hence, the electric force defined by $\boldsymbol{E}$ is only the electric force. But the recoil force should be dependent to the direction of $-(\boldsymbol{E}_1 \times \boldsymbol{H}_2 + \boldsymbol{E}_2 \times \boldsymbol{H}_1)$ or $-P$ which is at opposite direction of $\boldsymbol{x}_2 - \boldsymbol{x}_1$.

15.3 The Third law of Newton

The Third law of Newton has said the action and the reaction is same and the direction is opposite. Even Newton's law need the two objects one did the action another did the reaction, and the two object are closely contacted, but actually the two object are still separately a distance. In the above we have proved the recoil force are immediately, and the action and reaction are equal. We have know for light the energy divided the the speed of light is the momentum. When we obtained the momentum, use the momentum divided a time, which is action time T become the force,

$$-F_{reaction} =$$

$$\frac{1}{Tc}(-\int_{t=-\infty}^{\infty}\iiint_{V_1}(\boldsymbol{E}_2\cdot\boldsymbol{J}_1)dV)$$

$$=\frac{1}{Tc}Q=\frac{1}{Tc}\int_{t=-\frac{T}{2}}^{\frac{T}{2}}\iiint_{V_2}(\boldsymbol{E}_1\cdot\boldsymbol{J}_2)dV$$

$$F_{action} \tag{256}$$

Where T is enough large, or $T\to\infty$. Where F_{action} is the force act at the absorber. $F_{reaction}$ is the recoil force, act at the emitter. Because the above formula is a remote formula, it can be seen as the extension of the Newton's third law. In Newton's third law, what is the action and reaction, he didn't give a clear definition. But here the definition for action and reaction is clear.

F_{action} and $F_{reaction}$ are two positive scale values. They are force in the action and reaction direction. The average is done on the time period of T. The direction of action and the reaction is in the opposite direction.

Mechanics law of Newton has been explained. Newton third law is that the force of action and the force of the reaction is equal and in the opposite direction. This law can be expanded as a remote law. Assume there are two objects which are separate with a big distance, Assume the first object is the action object which will implement a action to the second object. Assume here the action and reaction is through the electromagnetic force. Now in the place of action object, for example an emitter, the reaction or recoil force is equal to the action force which is applied to the second object. In the place of the remote object, the action run from the action object (the emitter) to the reaction object (the absorber) needs a time T, the action and reaction is equal. The reaction will send to the action object (emitter) in negative time $-T$. Hence the reaction reach the action object at time $T+(-T)=0$. This means for electromagnetic force action and reaction even in the remote situation is still established.

The two objects can separated a very big distance. In this case, there still exist the expanded third law. That is the recoil force (reaction) which is equal to the force (action) to the remote object. The direction of the recoil force is in the opposite direction of the action force.

15.4 The momentum conservation of a photon

It worth to be mention that the action force direction are dependent to the direction of the mutual energy flow. The mutual energy flow,

$$(\xi_1, \xi_2) = \int_{t=-\infty}^{\infty} \oiint_{\Gamma} (\boldsymbol{E}_1 \times \boldsymbol{H}_2 + \boldsymbol{E}_2 \times \boldsymbol{H}_1) \cdot \hat{n} d\Gamma dt \qquad (257)$$

hence, the mixed Poynting vector,

$$\boldsymbol{S}_{12} = \boldsymbol{E}_1 \times \boldsymbol{H}_2 + \boldsymbol{E}_2 \times \boldsymbol{H}_1 \qquad (258)$$

corresponding energy flux intensity. Assume that the surface Γ is plane, and hence, $\hat{n}$ is a constant vector. Hence we can written,

$$(\xi_1, \xi_2) = \int_{t=-\infty}^{\infty} dt \iint_{\Gamma} (\boldsymbol{E}_1 \times \boldsymbol{H}_2 + \boldsymbol{E}_2 \times \boldsymbol{H}_1) d\Gamma \cdot \hat{n} \qquad (259)$$

$$\frac{1}{Tc}(\xi_1, \xi_2) = \frac{1}{Tc} \int_{t=-\infty}^{\infty} dt \iint_{\Gamma} (\boldsymbol{E}_1 \times \boldsymbol{H}_2 + \boldsymbol{E}_2 \times \boldsymbol{H}_1) d\Gamma \cdot \hat{n} \qquad (260)$$

we know that

$$\Psi_{flux} = \iint_{\Gamma} (\boldsymbol{E}_1 \times \boldsymbol{H}_2 + \boldsymbol{E}_2 \times \boldsymbol{H}_1) d\Gamma \cdot \hat{n} \qquad (261)$$

is the energy flux of the mutual energy package. Since we use mutual energy package to describe photon, this energy flux is also the photon flux,

$$Energy = \int_{t=-\infty}^{\infty} dt \iint_{\Gamma} (\boldsymbol{E}_1 \times \boldsymbol{H}_2 + \boldsymbol{E}_2 \times \boldsymbol{H}_1) d\Gamma \cdot \hat{n} \qquad (262)$$

is corresponding energy of a photon,

$$\boldsymbol{I}_{impulse} = \boldsymbol{P} = \frac{1}{c} \int_{t=-\infty}^{\infty} dt \iint_{\Gamma} (\boldsymbol{E}_1 \times \boldsymbol{H}_2 + \boldsymbol{E}_2 \times \boldsymbol{H}_1) d\Gamma \qquad (263)$$

is the corresponding momentum vector $\boldsymbol{P}$ of the photon, this moment is also a change of the momentum which is equal to the impulse $I_{impulse}$. The emitter applied to this impulse to the photon.

$$\boldsymbol{F}_{force} = \frac{1}{T} \boldsymbol{P} \qquad (264)$$

is the average of force in the time period T. $\frac{T}{2}$This force is the emitter offers to the photon (or the mutual energy package), hence the recoil force of the photon applying to the emitter should be,

$$\boldsymbol{F}_{recoil} = -\boldsymbol{F}_{force} = -\frac{1}{cT} \int_{t=-\frac{T}{2}}^{\frac{T}{2}} dt \iint_{\Gamma} (\boldsymbol{E}_1 \times \boldsymbol{H}_2 + \boldsymbol{E}_2 \times \boldsymbol{H}_1) d\Gamma \tag{265}$$

It is important to notice the mutual energy flow theorem guarantees the mutual energy flow are equal at any plane between the emitter and the absorber. This also guarantees the momentum of the photon is same at any surface Γ. This is the reason we can calculate the momentum above with any surface Γ. Hence the mutual energy flow theorem is also a momentum conservation theorem. It tells us the momentum of photon which described by the mutual energy flow is not change between the emitter to the absorber.

We know the mutual energy flow is derived from the field theory, however this field theory can offer a wave (the mutual energy flow) possess the momentum conservation, action force equal to the reaction force and in the opposite direction, energy conservation, it become a wave looks like a particle. Hence it can be referred as particle wave. A particle wave is a wave located in a region, moved like a particle. Hence the mutual energy flow indeed described the photon.

15.5 Mach's principle

It is know that Mach principle, the mass of a substance is because the substance of the whole universe give an action to the substance. March's principle offers the reason of the mass of that substance. It is clear this action should be nonlocal so that the substance in the universe even very far away can acted to the substance. Here we know at least the recoil action of the remote electromagnetic force can be immediately and hence nonlocal. This means if we accelerate a substance with mass m. This substance will produce a action to the substance of the whole universe. The reaction from the whole universe to this substance with mass m can be seen as a recoil force. This force will act at the the force try to accelerate the substance. Hence this recoil force can be seen as the inertia force. Hence we can fell the substance have a mass. But here the action and reaction is done by the gravitation force not the electromagnetic force. But we believe, for the gravitation there should be also some similar mutual energy flow theorem. Hence this mutual energy theorem can explain the Mach's principle.

15.6 The field theory vs the action-at-a-distance theory

We know that the concept of field come from the force line of Faraday. Maxwell has extended this concept as the fields. The field is measured by a test charge. However the Maxwell extended the concept. Maxwell believe that even the charge is removed, the field still exists. From this article, we have shown that is wrong. The field can only be corrected defined when there is a charge. Actually the theory of action-at-a-distance [28, 10, 30], the absorber theory [1, 2] debated this point with Maxwell's field theory hundred years. The absorber theory believe that the field is only a bookkeeper for the action, the field has no it's own freedom. Hence, only when there are at least two charge the action can be defined or calculated, and hence the field. The action and reaction is always take place at least between two charges. The argument even one charge can send radiation is wrong.

Our mutual energy theorem shows that the theory of the action-at-a-distance is correct, the field theory make mistake here. However the theory of action-at-a-distance is much complicate comparing with the field theory. The field theory is extremely simple. The field theory can be written as differential equations, which is only with local differential operator. The calculation of one point of the field can be done only from its neighbor. In contrast the action at a distance must consider to charges and a space between the two charges. If the two charges are not in the same coordinate frame, it become very complicated. Hence even the theory of action-at-a-distance is correct but it cannot win the field theory. Because, the theory of action-at-a-distance can also derive out the Maxwell equations, there always the place the calculation can not be done by the action-at-a-distance, but it can be solved with Maxwell equations and corresponding theory. According to the above argument, we can say that the field theory and the action at a distance each win 50%. There is no absolute winner.

After we derived the theory of mutual energy principle and the self-energy principle, we find the situation is changed. Fist the mutual energy principle and self-energy principle is still a field theory. The problem can be solved still by Maxwell equations and the time-reversal Maxwell equations. Hence the field theory updated and absorbed all the advantages from the theory of action at-a-distance. Now for this updated field theory, it does not need to worry about the wrong concept of fields.

We have said the correct definition of electric field is

$$\boldsymbol{E}(\boldsymbol{x}) = \begin{cases} [\boldsymbol{E}(\boldsymbol{x}_1,\boldsymbol{x}),\boldsymbol{E}(\boldsymbol{x}_2,\boldsymbol{x}),......,\boldsymbol{E}(\boldsymbol{x}_N,\boldsymbol{x})] & \boldsymbol{x} \notin X \\ \sum_{j=1,j\neq i}^{N} \boldsymbol{E}(\boldsymbol{x}_i,\boldsymbol{x}) & \boldsymbol{x} = \boldsymbol{x}_i \in X \end{cases} \tag{266}$$

But even we just consider the field can be superposed any place even where without a charge as the following,

$$\boldsymbol{E}(\boldsymbol{x}) = \sum_{j=1}^{N} \boldsymbol{E}(\boldsymbol{x}_i,\boldsymbol{x}) \tag{267}$$

$$\boldsymbol{H}(\boldsymbol{x}) = \sum_{j=1}^{N} \boldsymbol{H}(\boldsymbol{x}_i,\boldsymbol{x}) \tag{268}$$

When we calculate the energy, we consider the self-energy time-reversal return. The energy calculation is also the mutual energy principle. This is because, the Poynting theorem is,

$$-\nabla(\boldsymbol{E}\times\boldsymbol{H})=\boldsymbol{E}\cdot\boldsymbol{J}+\partial\boldsymbol{B}\cdot\boldsymbol{H}+\boldsymbol{E}\cdot\partial\boldsymbol{D} \tag{269}$$

Considering the superposition principle we have,

$$-\sum_{i=1}^{N}\sum_{j=1}^{N}\nabla(\boldsymbol{E_i}\times\boldsymbol{H_j})$$
$$=\sum_{i=1}^{N}\sum_{j=1}^{N}\boldsymbol{E}_i\cdot\boldsymbol{J}_j+\sum_{i=1}^{N}\sum_{j=1}^{N}\partial\boldsymbol{B}_i\cdot\boldsymbol{H}_j+\sum_{i=1}^{N}\sum_{j=1}^{N}\boldsymbol{E}_i\cdot\partial\boldsymbol{D}_j \tag{270}$$

Considering the self-energy principle,

$$-\sum_{i=1}^{N}\nabla(\boldsymbol{E_i}\times\boldsymbol{H_i})$$
$$=\sum_{i=1}^{N}\boldsymbol{E}_i\cdot\boldsymbol{J}_i+\sum_{i=1}^{N}\partial\boldsymbol{B}_i\cdot\boldsymbol{H}_i+\sum_{i=1}^{N}\boldsymbol{E}_i\cdot\partial\boldsymbol{D}_i \tag{271}$$

has no contribution to the energy transfer process, because there is the time-reversal process which cancel all self-energy items and self-energy flows,. From the N charge's Poynting theorem subtract the no contribution items of the above self-energy formula, we obtained that,

$$-\sum_{i=1}^{N}\sum_{j=1,j\neq i}^{N}\nabla(\boldsymbol{E_i}\times\boldsymbol{H_j})$$
$$=\sum_{i=1}^{N}\sum_{j=1,j\neq i}^{N}\boldsymbol{E}_i\cdot\boldsymbol{J}_j+\sum_{i=1}^{N}\sum_{j=1,j\neq i}^{N}\partial\boldsymbol{B}_i\cdot\boldsymbol{H}_j+\sum_{i=1}^{N}\sum_{j=1,j\neq i}^{N}\boldsymbol{E}_i\cdot\partial\boldsymbol{D}_j \tag{272}$$

We obtained the mutual energy principle, which can be used to calculate the correct energy. Hence, after we have the self-energy principle, the field can be superposed, but we should notice the energy calculation, that cannot use the Poynting theorem with N charges. The energy calculation must consider the self-energy principle. If we consider the self-energy principle, we can obtained the correct energy transfer formula. After we have the self-energy principle, The updated field theory can win the theory of the action-at-a-distance easily. The updated field theory is the theory with mutual energy principle and self-energy principle. The updated field theory has absorbed all advantage from the action-at-a-distance and absorber theory.

15.7 The recoil force

It need to be clarify about the recoil force of the waves. For a charge of the emitter, it sent the retarded wave and receive the advanced wave from the absorber, hence the people will think this charge has two force on it. The two force is the recoil force of the retarded wave and the the rcoil force exerted by the advanced wave.

However since the retarded wave is sent to the whole space to all directions, the total moment of this wave is 0. Hence even this wave has some "recoil force", that recoil force are 0. It is same for the advanced wave, the advanced wave can also not exert a recoil force to the the charge of a absorber. On the charge of the emitter, the is only the exerted force of the mutual energy flow which is,

$$\boldsymbol{F}_{recoil} = -\frac{1}{cT}\int_{t=-\frac{T}{2}}^{\frac{T}{2}} dt \iint_{\Gamma} (\boldsymbol{E}_1 \times \boldsymbol{H}_2 + \boldsymbol{E}_2 \times \boldsymbol{H}_1) d\Gamma \tag{273}$$

Only the mutual energy flow can offer a recoil force, the retarded wave and the advanced wave all cannot offer any recoil force, One thing is because this kind of force is applied at all directions, and hence the summation of the force is always 0. Even it is not 0, there are time-reversal waves which will also cancel all the effect of the force of all the self-energy items. The time-reversal waves can cancel the original self-energy wave even with any spoor!

16 The mistake in the absorber theory and the theory of Dirac

16.1 The problem of Dirac theory

The absorber theory try[1, 2] to explain the formula of the Dirac about the radiation of a accelerated or decelerated charge.

The Dirac equation is following,

$$\boldsymbol{F}^{damping}(x_j) = \frac{1}{2}(\boldsymbol{F}_j^{rect}(\boldsymbol{x}_j) - \boldsymbol{F}_j^{adv}(\boldsymbol{x}_j)) \tag{274}$$

Where $\boldsymbol{F}^{damping}(\boldsymbol{x}_j)$ is corresponding to the damping force exerted on the charge $\boldsymbol{x}_j$. The charge $\boldsymbol{x}_j$ accelerates or decelerates. $\boldsymbol{F}_j^{rect}(\boldsymbol{x}_j)$ is the retarded wave of the charge $\boldsymbol{x}_j$ has exerted a recoil force to the charge $\boldsymbol{x}_j$ and this recoil force is $\boldsymbol{F}_j^{rect}(\boldsymbol{x}_j)$. Dirac think the emitter also has advanced wave which also exerted a force to the emitter, but this force $\boldsymbol{F}_j^{adv}(\boldsymbol{x}_j)$ has the half value of the corresponding the force of the retarded wave. Hence the force exerted on the emitter is same as the force of the advanced wave exerted onto the emitter. The Dirac assume that,

$$\boldsymbol{F}_j^{adv}(\boldsymbol{x}_j) = \frac{1}{2}\boldsymbol{F}_j^{rect}(\boldsymbol{x}_j) \tag{275}$$

$$\boldsymbol{F}_j^{rect}(\boldsymbol{x}_j) - \boldsymbol{F}_j^{adv}(\boldsymbol{x}_j) = F_j^{rect}(\boldsymbol{x}_j) - \frac{1}{2}\boldsymbol{F}_j^{rect}(\boldsymbol{x}_j) = \frac{1}{2}\boldsymbol{F}_j^{rect}(\boldsymbol{x}_j) \qquad (276)$$

Actually Dirac found if use all energy send by the retarded wave to calculate the recoil force, the recoil force is doubled compare to the same value if the recoil force is calculate with other method. From where can obtained this fact $\frac{1}{2}$? He assume the advanced wave can have only apply half recoil force compare to the retarded wave. And the direction of the recoil force of the advanced wave is at opposite direction comparing to the retarded wave. This wave Dirac obtained the fact $\frac{1}{2}$.

In the last sub-section we have clarified, that the retarded wave and the advanced wave all cannot apply any force to the charge. The force can apply to the charge is only from the mutual energy flow. Hence the above argument of the Dirac is wrong. But if the recoil force is come from mutual energy flow. We have know the mutual energy flow can send a whole photon from emitter to the absorber. Dirac assume the retarded wave send a photon, he use the energy of photon to calculate the recoil force, it is larger than the result from other method. If we assume the photon energy is transferred by mutual energy, and use this photon energy to calculate the recoil force, it is same the we obtained a result 2 time larger than got from other method.

From where we can obtained the fact $\frac{1}{2}$? This is not difficult to explain. If the force is applied in all direction, then the total force is 0. If the force is applied in only one direction the total force can be obtained by the photon energy Q, the force is $\frac{1}{Tc}Q$. We have know that the mutual energy intensity vector

$$\boldsymbol{S}_{12} = \boldsymbol{E}_1 \times \boldsymbol{H}_2 + \boldsymbol{E}_2 \times \boldsymbol{H}_1 \qquad (277)$$

is not at same direction all from the emitter to the absorber. Hence the total force of the mutual energy flow should at between 0 and $\frac{1}{Tc}Q$. The author has not calculate this exactly, but it is very likely that the value is $\frac{1}{2}\frac{1}{Tc}Q$. Form the method of the mutual energy flow, we also can obtained the fact $\frac{1}{2}$.

16.2 The problem of absorber theory of Wheeler and Feynman

Got correct result, the force exerted onto to the emitter is only from the the mutual energy flow which is corresponding to $\frac{1}{2}\frac{1}{Tc}Q$.

However Dirac create the concept which is the retarded wave also exerted the recoil force to the emitter which is 2 time large than the force from the corresponding advanced wave, which is wrong.

This wrong is further developed by the absorber theory of the Wheeler and Feynman. In which, Wheeler and Feynman try to give a more detains explanation of the Dirac formula.

According to Wheeler and Feynman's absorber theory, that the total force exerted to a charge is

$$F^{tot}(x_j) = \frac{1}{2}\sum_{k=1,k\neq j}^{N}(F^{ret}(x_k,x_j)+F^{adv}(x_k,x_j)) \tag{278}$$

Hence,

$$F^{tot}(x_j) = \sum_{k=1,k\neq j}^{N}F^{ret}(x_k,x_j)+\frac{1}{2}\sum_{k=1,k\neq j}^{N}(F^{adv}(x_k,x_j)-F^{ret}(x_k,x_j))$$

$$= \sum_{k=1,k\neq j}^{N}F^{ret}(x_k,x_j)+\frac{1}{2}\sum_{k=1}^{N}(F^{adv}(x_k,x_j)-F^{ret}(x_k,x_j))-\frac{1}{2}(F^{adv}(x_j,x_j)-F^{ret}(x_j,x_j)) \tag{279}$$

Wheeler and Feynman said that,

$$\sum_{k=1}^{N}(F^{ret}(x_k,x_j)-F^{adv}(x_k,x_j))=0 \tag{280}$$

Hence,

$$F^{tot}(x_j) = \sum_{k=1,k\neq j}^{N}F^{ret}(x_k,x_j)+\frac{1}{2}(F^{ret}(x_j,x_j)-F^{adv}(x_j,x_j))$$

$$= \sum_{k=1,k\neq j}^{N}F^{ret}(x_k,x_j)+\boldsymbol{F}^{damping}(x_j) \tag{281}$$

Where,

$$\boldsymbol{F}^{damping}(x_j) = \frac{1}{2}(F^{ret}(x_j,x_j)-F^{adv}(x_j,x_j)) \tag{282}$$

What is wrong here?

$$F^{tot}(x_j) = \frac{1}{2}\sum_{k=1,k\neq j}^{N}(F^{ret}(x_k,x_j)+F^{adv}(x_k,x_j)) \tag{283}$$

is wrong, there is not the thing call retarded force and advanced force, the force is applied only by mutual energy flow, the mutual energy flow is consist of the retarded wave and the mutual energy flow. Pure retarded wave and pure advanced wave can not apply any force to the charge. Hence the absorber theory also make mistakes.

Any way about the recoil force, we should calculate according to the mutual energy flow, since the mutual energy flow intensity is not at the same direction, the whole force is less the force calculate according the whole photon energy package.

16.3 Half advanced and half retarded potential

In the absorber theory, it suggest that the solution of the Maxwell equations are consist of two kind of potential, retarded potential and advanced potential. It is called half retarded and half advanced potential,

$$\boldsymbol{\xi}(x_j) = \frac{1}{2}(\boldsymbol{\xi}_j^{rect}(\boldsymbol{x}_j) + \boldsymbol{\xi}_j^{adv}(\boldsymbol{x}_j)) \tag{284}$$

In the author theory of mutual energy, we did not assume the current produce half retarded and half advanced potential. We assume it is ether an emitter or an absorber. It does not become both. However we do not reject in some case that a charge can be a emitter or a absorber in the simultaneously. For example in the scattering situation, a scatter is an absorber because it receive a photon. In the same time it is an emitter, it will radiate a photon. In this case, it is clear for this charge, it sends a advanced wave to receive a photon, it sends the retarded wave to emit a photon. However any scatter can be seen as as two separated charges, one is emitter the other is the absorber. Just the two charges are put to a same location. In most situation, the charge has only one task, it is ether an emitter or an absorber.

In author's mutual energy theory, it is important to have synchronized two charges, one charge sends retarded wave and another charge sends advanced wave. We also do not assume the half potential. The fact $\frac{1}{2}$ in the above formula make things more complicate. Hence even the author support the concept of exist of advanced wave, the half retarded potential and half retarded potential is not used.

In the author's theory of mutual energy, even an emitter has sent a advanced potential in the same time when it sends a retarded potential, since the advance potential has not matched with any retarded potential, it is balance out by a time-reversal process. If this advanced wave just matched with a retarded potential, then this charge become a scatter. A scatter can send retarded potential and advanced potential simultaneously. Hence it is not necessary to assume a half retarded and half advanced potential. But the author theory also doesn't reject the concept that any current $\boldsymbol{J}$ will sent retarded wave and advanced wave simultaneously.

17 Advanced wave or receiving wave?

We have assume that the absorber sends out the advanced wave, which is sent from the current time to the past time. The question is that this wave happens before the source of absorber current $\boldsymbol{J}_2$, it is a wave from infinite concentrating to the place of the absorber, is this wave can control the current $\boldsymbol{J}_2$ or the current $\boldsymbol{J}_2$ can control this wave? If the wave can control the current $\boldsymbol{J}_2$, we will call this wave as a receiving wave, because it is only responsible to receiving the energy. If the current $\boldsymbol{J}_2$ in the absorber can control this wave, we will call the wave as advanced wave. Advanced wave is controlled by the current source. Because the advanced wave is a solution of Maxwell's equations, in which the source $\boldsymbol{J}_2$

is known. Perhaps the wave can control the current $\boldsymbol{J}_2$ but the current $\boldsymbol{J}_2$ also can control the wave, in this case we will also call the current $\boldsymbol{J}_2$ as advanced wave.

We have known in the normal electricity situation, if we have a transformator, we can put electric current inside the primary coil, we know that it can induct a current in the secondary coil, if the second coil has a load. We also know that if we increase the current of the second coil by changing the load of the second coil, the primary coil also must offer more power by increase the energy of the first coil offering. Up to here there is nothing new, it just normal knowledge of the electric circuits. However if we separate a big distance to the primary coil and the secondary coil, it is clear that the secondary coil will still receive power from the primary coil, even it received much less than before, for example only 1 percent (1%) of the power from the primary coil. In this case actually the two coils become two antennas, the primary coil become a transmitting antenna, the secondary coil become the receiving antenna. The receiving antenna can receiving 1 percent of power from the transmitting antenna. Now suppose we increase or decrease the current $\boldsymbol{J}_2$ in the receiving antenna, what will happen? If the receiving antenna (or the secondary coil) really sends an advanced wave out, when this current $\boldsymbol{J}_2$ is changed, it will sends a bigger $\boldsymbol{E}_2$ to the transmitting antenna, and $\boldsymbol{E}_2$ will suck more energy from $\boldsymbol{J}_1$. Hence the transmitting antenna must send more power out. This means the current of the the transmitting antenna (in the primary coil) is also changed. However since the wave sent by the secondary coil is a advanced wave, the current in primary coil will receive this signal at a time before the $\boldsymbol{J}_2$ is changed. This way we have sent a signal to the past.

We can easily do this experiment in normal wireless or microwave frequency band, it is not cost a lot. Since doing this experiment do not need second signal transferring channel like in quantum mechanics. We perhaps can really send a signal to the past. That will be a very interesting experiment.

How to change the load of the secondary coil? One method is to let the load of the second coil to connect to a wireless receiver. The receiver is made by a very simple regeneration amplifier. If a regeneration signal is feedback to the input of the amplifier, the input current which is $\boldsymbol{J}_2$ is changed, it will induce a change at the current in primary coil $\boldsymbol{J}_1$. We assume the amplifier is very fast, hence the regeneration signal do not has any delay. This way we can send a signal to the past.

Any way, even this experiment failed, that means the wave connected with $\boldsymbol{J}_2$ is a receiving wave, it can offer a influence to current $\boldsymbol{J}_2$, but cannot receive the influence from $\boldsymbol{J}_2$. In that case we perhaps need to change the name of the advance wave as something else, for example, the receiving wave or concentrated wave. But the most our theory above is still correct. If we can send the signal to the past, that will further prove the theory about the advanced wave and advanced potential is real physical concept.

18 Why we need to introduce the two new principle?

From the above discussion, it looks that we still need the Maxwell equations why we introduce the two other principles, i.e. self-energy principle and mutual energy principle?

Actually we still can keep Maxwell equations as the axioms of electromagnetic fields and add the time-reversal Maxwell equations as the axioms of the electromagnetic field theory. But there are some difficulties which are too difficult to overcome. Maxwell equations have two solutions one is retarded wave, another is advanced wave. From Maxwell equations it is not clear what is the relation between these two waves. For a photon, there are two charges involved, one is the emitter and another is the absorber. If we take Maxwell equations as axiom then the emitter will continually sends out the retarded waves. The absorber will continually sends the advanced waves. This two things are not related and hence, it is difficult to obtained the important result that the retarded wave and the advanced wave have to be synchronized. Starting form Maxwell equations the most people cannot accept the advanced wave and will think it is non-causal. And hence, every thing just stop there. In other hand if we started from the mutual energy principle, it automatically ask that the two waves the retarded wave and the advanced wave must be synchronized. Only the synchronized two waves are possible solution of the mutual energy principle. Only that kind of solution of physical solution. Here we have assume that for the light wave, it is a very short impulse, which are randomly sends out by the emitter and absorber. Only the synchronized retarded wave and advanced wave can be the nonzero solutions of the mutual energy principle. This force people to accept the advanced wave. The two waves synchronized is a random events that is because the emitter randomly sends the retarded wave and the absorber randomly sends the advanced wave. This also explain that why the place of the photon appearing is always with a probability.

We recognize the electromagnetic field is a step-by-step process. In the beginning there are Faraday's law of induction, Ampere's low, and two Gauss's law. Maxwell found these four laws are not self-consistent. The 4 equation conflict with the current continuous equation. Maxwell introduced the concept of displacement current. After adding the displacement current item to the Ampare's law, the 4 equations become Maxwell equations. Maxwell equations now are consistent with the current continuous equation. The Maxwell equations overcomes the difficulty of inconsistency. This problem of the four equations are not consistent is solved.

The superimposition principle is also accept as a law which is not related from Maxwell equations. The Poynting theorem can be derived from the Maxwell equations. Apply the Maxwell equations and the superimposition principle, the author found that the Poynting theorem for N charges has an over estimation to the power for a system with N charges. This means the Maxwell equations together with the superposition principle conflict to the energy conservation.

The author believe if the Maxwell equations and superposition principle conflict with energy conservation, the wrong side is at the Maxwell equations or the superposition principle.

Energy-over-estimated items are self-energy items. Let all energy-over-estimated items be zero. This is referred as self-energy conditions. Considering the self-energy conditions, we can take away the items of all over estimations in N charges of the Poynting theorem, this way we get the mutual energy principle. Hence the mutual energy principle does not conflict with three things. (a) Maxwell equations, (b) superposition principle, (c) energy conservation condition. Hence the author would like to use the mutual energy principle as axiom for the whole electromagnetic field theory.

The author solved the mutual energy principle which further leads the Maxwell equations again. But the author found not all the solutions of the Maxwell equations are the solution of the mutual energy principle. There are two kind of solutions, one is retarded wave another is advanced wave. Mutual energy principle only accept that one solution is a retarded wave and another is advanced wave and they must matched with each other. That means the retarded wave must synchronize with the advanced wave. When the two waves are synchronized, the two waves can produce the mutual energy flow which can carry the energy from the emitter to the absorber. The author realize that this energy flow just is the photon. The author found in order to support the mutual energy flow, there should has also the self-energy flow. The self-energy flow cannot be zero all the time. The self-energy flow help the mutual energy flow to work. The self-energy nonzero conflicts to the self-energy conditions which says that all this self-energy items should vanish.

We know that the self-energy flow spread their energy to the entire space, originally we will perhaps think that there is a wave function collapse process hence the self-energy flow will also transfer part of energy. For example in a two-charge photon system (in which there is an emitter and an absorber, a photon energy is sent form the emitter to the absorber) the self-energy flow of the retarded wave and the self-energy of the advanced wave will transfer part of the photon energy. The photon energy will not only be transferred by the mutual energy. However from above self-energy principle, it tell us that all self-energy items should vanish. all self-energy items does not carry energy. This force the author to think that the self-energy flow is not collapse but there is a time-reversal return process. The self-energy flow corresponding to retarded wave and advanced wave both have the corresponding time-reversal return processes.

Hence the whole theory of electromagnetic field is built. This author also check in case of wireless or microwave situation. In this case we have know the Maxwell theory is worked well. To make the theory consistent, we must prove in macroscopic situation, Maxwell's theory is still correct at least approximately. This is sames to build the the macroscopic wave from infinite particle-wave of the photon. We know for photon it satisfy the mutual energy principle and self-energy principle, hence what we need to do is prove the MCMEQ from the mutual energy energy principle and the self-energy principle. Since we cannot apply superposition principle which is not correct. We cannot prove MCMEQ with superposition principle and SCMEQ. However we can use mutual energy principle with the infinite charges to prove the Poynting theory. We did that. Since Poynting theory is actually equivalent to Maxwell equations, even we cannot prove this in mathematics. The solution of the Poynting theorem is also the Maxwell equations. This way the author believe that we have obtained the macroscopic Maxwell equations.

Now we got the MCMEQ the Maxwell equations for macroscopic situation. Please notice that in our derivation we have put infinite absorber at the infinite big sphere. Hence the Maxwell equations of this article is not equivalent to the traditional Maxwell equations which does not need the absorbers to distribute in the infinite big sphere uniformly.

After we obtains both SCMEQ and MCMEQ, This also means the superposition principle principle is also OK. Here the author means the superposition principle is OK that needs also the condition that the absorbers distribute at the infinite big sphere.

In classical electromagnetic field theory, there are superimposition principle, hence deriving the Maxwell equations of N charge from the Maxwell equations of single charge is trivia. But in the author's theory, the superimposition principle is problematic and hence does not available. Hence, both the Maxwell equations for single charge or for many charges are not equivalent. However, since for the mutual energy principle for 2 charges or N (many) charges, are still same in the mutual energy principle. We have proved that the mutual energy principle is suitable to the classical electromagnetic field theory. After this the mutual energy principle and the self-energy principle successfully united the two fields (1) the theory for wireless wave or microwave, (2) the theory for light wave.

18.1 The field of the emitter and the absorber

Eq.(53) can be referred as mutual energy formula, which is closed related the mutual energy theorems, [31],[15, 34, 33, 19]. and [8]. This mutual energy formula is correct in two ways. (1), it can be derived from MCMEQ or from Poynting theorem. If MCMEQ is correct this formula is also correct, it is easy to prove this. Because we take away all self items which also satisfy Poynting theorem for a single charge. From the Poynting theorem of N charges take away all corresponding Poynting theorem for single charges, this guarantees the rest items still correct if Poynting theorem is correct. Since Poynting theorem can be derived from MCMEQ, the rest items also satisfy MCMEQ. (2) The second way to show this formula is correct because it satisfies also the action-at-a-distance principle[10]. The action-at-a-distance principle actually tells us that the action and reaction can only happens between two charges, there is no any action or reaction in space sends by a single charge. The action-at-a-distance principle has been further developed to as the adjunct field theory of Wheeler and Feynman[2]. The mutual energy formula Eq.(53) is agreed with the action-at-a-distance theory and can be seen as a new definition of the so called adjunct field. Wheeler and Feynman did not point out this formula, they developed a new QED (theory quantum electrodynamics) from their adjunct field theory. Wheeler and Feynman try abandon the classical electromagnetic theory in quantum physics where only a few charges is involved (N is very small).

If someone claim he find a new theorem which is the above mutual energy formula Eq.(48), no any journals can accept it, because it just a direct deduction of Poynting theorem. However we will show that since Maxwell equation, Poynting theorem, superimposition principle all has problems, only this formula is still correct, hence it should be applied as an axiom of the electromagnetic theory.

About the the self-energy formula Eq.(49) which is the Poynting theorem for single charge. It need to be taken out that means this formula is problematic. If single charge has a current change $\boldsymbol{J}_i$, according to the Maxwell's theory there is a real physical wave sent from this current change. According to quantum physics double slit experiment, this wave is not a real wave but a probability wave. Experiments shows that the photon is only randomly received by the absorbers which can receive the wave sent out from the emitter charge with current change $\boldsymbol{J}_i$. Traditionally, the people thought that Maxwell's theory is only suitable to the wireless wave which has lower frequency, it is not suitable to the high frequency phenomena like photon. Photons needs quantum theory, quantum electrodynamics or quantum field theory to solve. This author believe the suitable revises from electromagnetic field theory of Maxwell can still keep this theory alive, even with the light frequency. The key of this is to take out the self-energy items Eq,(49) from the Poynting theorem Eq.(44). Which lead the author to have introduced the self-energy principle. In the self-energy principle two time-reversal waves corresponding to the retarded wave and advanced wave are introduced. The time-reversal waves satisfy the time-reversal Maxwell equations which are not Maxwell equations.

19 Conclusion

19.1 What have done

This article discuss how to solve the wave-particle duality. The author started from the Maxwell equations and superposition principle. The author thought that the photon should also satisfy these two conditions. Moreover the author adds an additional condition, energy conservation condition. Originally with Maxwell equations, and superposition principle, the electromagnetic field can be solved. When a new condition is added on the top of the two conditions, too many condition will make the system without a solution. This is called conflict. When conflict happens the author has to solve the conflict. This leads the self-condition. The self-condition tells us that the energy items and the self-energy flow must vanish at all. From this the author obtained the mutual energy formula, the author found that the mutual energy formula do not conflict with all the above 3 conditions. Because the above 3 condition conflict with each other, the author call the mutual energy formula as mutual energy principle. It is used as axiom of the author's new electromagnetic field theory. This theory works also with photon.

Maxwell equations can be derived from the mutual energy principle. However, this time the Maxwell equations are not original Maxwell equations, this time there are additional conditions to the Maxwell equations. The Maxwell equations must be a pair, one is applied to the retarded wave and another is applied to the advanced wave. The two groups of Maxwell equations must be synchronized together. The together synchronized two waves produces the mutual energy flow which is a photon's energy flow. This way in the author's theory the advanced wave cannot be avoid.

It noticed that the Maxwell equations are not always correct. For single charge even it is moved with acceleration or deceleration, there is no any field can be sent out if this wave did not find a counterpart wave to match. Hence in this time the Maxwell equations are not correct. Maxwell equations are only partially correct or correct in some probability.

If there are two waves synchronized, one is retarded wave one is for the advanced wave, in this time the two groups of Maxwell equations are satisfied. Even Maxwell equations are only partially correct or correct in some probability, they still need the self-energy flow do not vanish. This is conflict with the self-energy condition. The self-energy condition require that all the self-energy items, the self-energy flow must vanish. This is second time the author meets a conflict. In this time in order to solve the conflict, the author has added 2 time-reversal waves, one is corresponding to the retarded wave, one is corresponding to the advanced wave. The time-reversal waves balance out the two self-energy or self-energy flows of the retarded wave and the advanced wave. The self-energy flows and the time-reversal self-energy flow together will cancel each other and do not produce any energy flow. The energy flow between emitter and the absorber is produce by the mutual energy flow which is built with the retarded wave of the emitter and the advanced wave of the absorber.

This way a photon can be described. The photon is produce by 4 waves instead of one or two waves, i.e. the retarded wave, the advanced wave and the two corresponding to time-reversal waves. There are 6 energy flows. Corresponding to the 4 waves there are 4 energy flows, but the retarded wave and the advanced wave can produce an additional energy flow which is the mutual energy flow. The two time-reversal waves also produce a time-reversal mutual energy flow. Hence there are two mutual energy flow. The mutual energy flow is responsible to transfer the energy from emitter to the absorber. This energy is the photon's energy. The time-reversal mutual energy flow is applied in case a race condition happened. In case of race, the time-reversal mutual energy flow is responsible to bring the energy of a half photon back to the emitter.

Since in the author's theory the energy can flow from absorber back to the emitter, the energy can vibrate back and forth, this guarantees that the energy can flow on the detector screen. This looks like a wave function collapse process. Hence the wave function collapse process is also solved with the 2 mutual energy flows and the 4 self-energy flows together.

19.2 The self-energy and the mutual energy principles

This article describe the self-energy principle in details. First we notice there is a over estimation for the power of a system with N charges. This over estimation leads to all self-energy items in Poynting theorem for N charges vanish, which in turn leads to the mutual energy principle. The mutual energy principle is suitable to a electromagnetic system with at least two charges. The mutual energy principle for a system with only two charges can explain a normal photon. A photon is a electromagnetic system with two charges. One charge is the emitter and another charge is the absorber. From the mutual energy principle we have know that if the emitter randomly send retarded wave and the absorber randomly send advanced wave, when the two waves are synchronized, the mutual energy flow is produced, which is the photon. Since the emitter and the absorber satisfy the Maxwell equations, which leads to that the self-energy flow should not vanish which in turn conflict with the self-energy condition. This conflict in turn leads this author to introduce a time-reversal wave, which is a time reversal process. The time-reversal waves, hence, should satisfy the time reversal Maxwell equations. This time-reversal wave balance out all self-energy flow and self-energy items. This also avoids a wave function collapse process. After this two principles are introduced, the whole electromagnetic theory includes the wireless frequency band and light frequency band are all united.

After we have introduced the self-energy principle, in which the time reversal process for the retarded wave and advanced wave are introduced, all the waves are physical waves, which satisfy the mutual energy and the self-energy principles. The probability phenomenon of the photon is also offered a good explanation. Photon is a system with two charges, one is the emitter, another is the absorber. The emitter from higher energy level jump to lower energy level and randomly sends the retarded wave. The absorber from lower energy level jump to a higher energy level and randomly sends the advanced wave. These waves are very short time signal. In case the retarded wave and the advanced wave just take place in the same time, the two waves are synchronized, the mutual energy flow is produced, which is the photon. No mater the mutual energy flow is produced or not the self-energy items and self-energy flows are time-reversal returned with a time-reversal process which satisfy time-reversal Maxwell equations.

In this electromagnetic theory, the superimposition principle for the electromagnetic fields are not assumed, since it is problematic. The field can be superposed only at the charge. In the space where without a charge, if all field are superposed, the energy will have a overestimation. In the place of a charge, the field is also defined by all other charge do not include the charge itself. It lucky that the theory of the self-energy principle and the mutual energy principle do not dependent to the superposition principle.

Maxwell equations are also not used as axioms, since the relationship of the two solutions retarded wave and advanced wave cannot be clearly obtained from them, which can only be obtained by the mutual energy principle. If Maxwell equations are used as starting point, the people always will ask, there are two solution one is retarded wave and another is advanced wave, are them all physical solutions? Another reason Maxwell equations are not applied as axioms is that the superimposition principle is problematic, even Maxwell equations for single charge is correct we cannot from them to deduce that the Maxwell equation still correct for N charges. This reduce the usefulness of Maxwell equations. Started form Maxwell equations can also very difficult to obtained the time-reversal waves.

Instead the Maxwell equation, the self-energy and the mutual energy principles become the axioms of the electromagnetic theory. This theory will cover all frequency bands, for example wireless wave, microwave, light wave, x-ray wave and gamma wave and so on. In author's theory Maxwell equations are only correct, in case there are at least two group equations, one is for the emitter and another one is for the absorber. Any waves sent by single charge has no effect to other world since there is a time-reversal wave just balance out or canceled it. In this case we can think the Maxwell equation is wrong, or we can think it is correct, but since there is a time-reverse-return wave which has balance out all energy flow send out. Hence the wave described by the Maxwell equations does not transfer any energy.

19.3 New results for electromagnetic field theory and photon theory

(1) photon is system which consists of 4 waves and 6 energy flow instead of 1 wave and 1 energy flow.

(2) Maxwell equations are only partially correct or correct with some probability. This explained the reason why in quantum mechanics the wave is probability wave. The author have added two time-reversal Maxwell equations to the original Maxwell equations, hence now a photon is consist of 4 waves. These 4 wave will created 4 energy flow. There are two additional energy flow, the mutual energy flow and the time-reversal energy flow.

(3) The superposition principle are wrong. The field can only be superposed at the position where there is a charge. In the place of charge, this charge cannot be included in the calculation of the field. In any other place where there is no charge, the energy and energy flow can be calculated through the mutual energy principle where summation is $\sum_{i=1}^{N}\sum_{j=1,j\neq i}^{N}$, instead of $\sum_{i=1}^{N}\sum_{j=1}^{N}$.

(4) The Poynting theory for N charges are wrong. Poynting theory for N charges tell us that there are energy flow from this N charge go outside the infinite big sphere, which lead the energy lose to the outside of our universe. That is wrong. The correct results are take out all the self-energy items. After take out all self-energy items, the mutual energy principle is obtained. The mutual energy principle is correct. Which can be see as updated version of energy law compare to the Poynting theorem.

(5) We have obtained the mutual energy theorem. This new mutual energy flow theorem is a much stronger results compare to old mutual energy theorems[31],[27],[15, 34, 33] and [8]. The old mutual energy theorem tell us

that there is part of energy sent from transmitting antenna will be received by the receiving antenna. That means the most energy sent from the transmitting antenna has sent to other place instead of the receiving antenna. The new mutual energy theorem tell us that all the energy sent out from the emitter is received by the absorber. There is no any energy sent from the emitter is lost to the empty space. This energy sent by emitter is received all by an absorber. This energy just describes the photon. We also introduced the mutual energy flow theorem, which tells that the energy transferred in any complete surface between the emitter and the absorber are equal to the the energy of the photon. The mutual energy flow is a inner product between the retarded wave and the advanced wave.

(6) The mutual energy flow is thin in two ends close to the emitter and the absorber, and the mutual energy flow is thick in the middle between the emitter and the absorber. Hence it is the so called particle wave. It allows this wave to look like a particle at two ends and to look like a wave in the middle between to ends. If the mutual energy flow go through a double slits in a separation board, it is clear the interference patterns will be created. In the place the wave is sent by the emitter and the place the energy is received by absorber the energy will be concentrated to a very small region which looks like a particle.

(7) Self-energy flows do not transfer any energy from emitter to the absorber. 4 self-energy flows all cancel or balance out. The energy is transferred only by the mutual energy flow. The time-reversal mutual energy flow is responsible to return the half photon from the absorber to the emitter in case of race or half photon situation happens.

(8) The author obtained the energy conservation for the wave of the photon. The retarded wave of Maxwell equations cannot make the energy conservation. The energy sends out from a emitter go all different directions and do not run to the absorber, it need a wave function collapse process to make energy conserved. But wave function collapse does not have any formula to describe and hence is a very rough theory. Our mutual energy flow theorem guarantee the energy is flow from emitter to absorber, the mutual energy flow theorem tell us in any surface between the emitter and the absorber the energy flow are all equal. This guarantees the energy is conserved.

(9) The momentum is also conserved. We know even the wave collapse can make energy conserved for the retarded wave of Maxwell equations, it still cannot make the momentum conserved. The retarded wave sent from the emitter to all directions and hence the total momentum is 0. But when the absorber received the momentum, the momentum is not zero (the direction is from the emitter to the absorber). We have the mutual energy flow theorem which also guarantees the momentum is sent from the emitter to the absorber and hence the momentum is also conserved.

(10) The macroscopic theory of the electromagnetic field theory can be obtained from the particle wave of the photon which is the mutual energy principle and self-energy principle. Hence, the infinite particle wave can build a macroscopic wave. The macroscopic Maxwell theory is still correct, if there are infinite absorbers which are distributed on the infinite big sphere. The superposition

principle for the macroscopic wave is still correct approximately.

(11) In this theory shows it is clear that the mutual energy theorem and the mutual energy flow theorem is a correct energy theorem and physical theorem. Then it is also clear that the Lorentz reciprocity theorem is only a mathematical transform of the the mutual energy theorem. The Lorentz reciprocity theorem can be obtained from the mutual energy theorem with a conjugate transform. The conjugate transform modified the advanced wave to a retarded wave. Hence in the Lorentz reciprocity theorem the advanced field will not appear. Many people do not accept the advanced wave, hence they like the Lorentz theorem. However Lorentz theorem is only an artificial theorem which hidden the advanced wave and the mutual energy theorem. However this article also shows the advanced wave exist. The receiving antenna should send the advanced wave instead the retarded wave or do not send any wave.

(12) The author has introduced a new interpretation for quantum mechanics. It can be referred as the mutual energy flow interpretation of quantum mechanics. This interpretation is similar to the transactional interpretation of John Crammer, because the retarded wave and advanced wave are all applied.

In the new interpretation the probability wave is because the Maxwell equations are only correct partially. Actually the retarded wave is sent by the emitter randomly and the advanced wave is sent by the absorber randomly. Only when they are synchronized, the photon energy can transfer from emitter to the absorber. The Maxwell equations are correct this time. Otherwise the energy flow of the corresponding Maxwell equations are time-reversal returned to the emitter or absorber and hence doesn't have any effect.

The collapse process can be seen as the together with the mutual energy flow transferring the energy and the time-reversal process of all self-energy. In the author's theory the race situation is also no problem, half photon is allowed to be returned to the emitter through a time-reversal mutual energy flow. Comparing to the transactional interpretation of John Crammer, the author's theory is not only a interpretation, it is a whole theory with details and formulation. Especially 4 additional time-reversal Maxwell equations are added to the original Maxwell equations which remedy the original Maxwell theory.

(13) Compare to the theory of action-at-a-distance, originally the Maxwell's field theory is only mathematically simpler than the action-at-a-distance theory, but it contains conflicts. Now with the self-energy and mutual energy principle the field theory is remedied, the conflict is eliminated. It is not only simpler but also correct compare to the theory of the action-at-a-distance.

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